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The placement of the technician in our society was defined: The technician is not a retrained craftsman nor a flunked-out engineering student. He is a new and unique aspect of technological society. Three levels of technicians are described: the engineering technician, the industrial technician, and the technical specialist. There is a large gap between abstract engineering and production, and the technician should bridge this gap. The current shortage of technicians, and industry's preference for trained personnel, serve as mute evidence that current and past practices of determining curriculum content are less than satisfactory.

The basic instrument used to collect data was a modified version of the Q- sort technique. Cards were developed to represent the content of courses taken by technicians in preparation for various jobs.

Assessing the educational attainment of the respondents helped to clarify some of management's viewpoints concerninghiring practices. High School programs are good but the traditional college program, with its emphasis on science and math, is more in line with the needs of technician-positions.

Analyses were used to identify the core program and specific areas of knowledge related to the separate technologies. The core program knowledges were found to include technical writing, engineering graphics, math through trigonometry, and the use of test equipment. The findings indicate that due to a similarity of curriculum the requirements of technology are included in the academic offerings of the typical junior college.

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UNIVERSITY OF ILLINOIS

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Curricula Content For Technical Education

Cooperative Research Project No. 2048

William John Schill

University of Illinois

1964

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William John Schill

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CHAPTER I

INTRODUCTION

Change is not new to the occupational setting. Through the years, occupations have evolved from trade or mercantile occupations into professions. They have also had their mutations based upon increasing need for specialization or in some cases, decreasing need for specialization. These changes have manifest themselves in many and diverse occupations. In some respects, the civil engineer of yesterday is the surveyor of today; and yet, if we look at the same occupation in a different light and consider the increasing amount of knowledge required of the civil engineer, we could conceive of the situation being the reverse where the surveyor of yesterday is the civil engineer of today. Regardless of the perspective, it is obvious that change has taken place.

There have been numerous changes in the occupations allied to the manufacturing industries. An example of the transition from generalist to specialist to technician can be drawn from the area of metal working. The transition went from (1) the generalist in the form of the blacksmith who was responsible for forging, heat treating, machining, welding, the whole gamut of metal working to (2) the specialist (such as a welder) concerned with only one or two of these functions to (3) more specialization that required background in the sciences applied to the occupation which brought about the metallurgist and other quasi-technical positions. This evolution has continued to the point where it is conceivable that a person now involved in the metal working industry is required to have knowledge beyond the structure of metal and its characteristics; he must also be familiar with and able to apply X-ray, spectograph, and electronic equipment to assess the stability, strength, and ductility of the metals. In a sense, the evolution in the metal working field is typical of evolution in a variety of other industrial fields in that we have gone from generalist to generalist; but in the process, we have incorporated into the knowledge necessary to fulfill the function of the occupation an increasing reliance upon the physical, natural, and mathematical sciences upon which the industry is predicated.

Changes in occupations also involve changes in sociological structure and resulting status and societal implications. Thus, there has been an evolution in some cases from less than professional status to professional status, while there has been a regression in still other occupations from semi-professional to trade craft or semi-skilled occupational status. Both the sociological changes and the changes in the functions in the occupations have dictated alterations in the educational structure designed to prepare people for a productive place in our industrial society. One of the prime examples of the changing emphasis in education can be found in the colleges of engineering. The colleges of engineering have gradually divorced themselves from practical application of the abstract concepts of the sciences. This, in turn, has contributed to the increasing need for a new group of occupations that we have recently begun to call the technical occupations.

There is an underlying assumption upon which the changing emphasis of our educational institutions seems to be based. Even though there is continued postponement of entrance into the labor field, there is insufficient time for an engineer to master both the abstract scientific concepts which contribute to the development of new processes and techniques and the practical application of those concepts. With the increasing diversity of materials available to industry, and the concomitant requirement that the skilled and semi-skilled personnel be able to manipulate these materials in the formation of consumer and defense products, it follows that the craftsman and the skilled operators in industry should concentrate on mastering the machine processes necessary for ultimate production. This situation is manifest by a huge gap between abstract engineering and production into which the technician is thrust.

The technician finds himself in a unique situation. He must have the basic knowledge to communicate with the engineer and scientist; in addition, he must have a working knowledge of the production set-up in order to facilitate the prototype construction and the practical assessment of theoretical or abstract physical science phenomena directed toward the production of consumable products.

THE DEFINITION OF TECHNICIAN

The most common element of current publications on technician and technical education is the confusion that exists in defining a technician. Too many of the definitions are predicated upon statements that refer to his formal educational background or that use the word "technical" within the definition. The descriptions that do have a common element are largely those that describe the technician's functions in relation to the role he plays in the engineering and scientific function.

To label the various areas in which technicians are employed as being engineering, industrial, or service does not contribute to a clarification of the functions of a technician. Most, if not all, of the schema for categorizing technicians are predicated upon traditionally oriented educational programs and might as well be identified with crafts such as machining, welding, automotive repair, and printing. Real understanding of the place of the technician in our current industrial society requires a rethinking through of the entire industrial process and industrial organization.

Of all the groups who have contributed to the current confusion over the definition of technicians, educators are undoubtedly the most to blame. They have added the proliferation of technological courses to their curriculum. These are predicated mainly upon the craft oriented emphasis that has been in existence since the early 1900's and upon the vocationally oriented aspects of the public school program. Educators have "bought in" on the term "technology" to attempt to give status to the programs that exist. These programs could not be changed drastically because of (1) the tenure involvements with teachers, (2) the commitment of capital outlay, and (3) lack of concern for the advancing knowledge in the area of industrial activity.

The definition of a technician cannot be predicated upon some past concept of occupational classification. He is not necessarily a revamped or flunked-out engineer, nor necessarily is he a reeducated craftsman. He is a new and unique aspect of technological society.

For the purposes of this research project the definition of technician used was the one proposed by the President's Committee on Scientists and Engineers:

> The engineering or scientific technician is usually employed in (1) research, design, or development; (2) production, operation, or control; (3) installation, maintenance, or sales. When serving in the first of these functional categories, he usually follows a course prescribed by a scientist or engineer but [may or] may not work closely under his direction. When active in the third category, he is frequently performing a task that would otherwise have to be done by an engineer.
>
> In executing his function, the scientific or engineering technician is required to use a high degree of rational thinking and to employ post-secondary-school mathematics and principles of physical and natural science. He thereby assumes the more routine engineering functions necessary in a growing technologically based economy. He must effectively communicate scientific or engineering ideas mathematically, graphically, and linguistically.[1]

Inherent in the above is the need to identify the basic area in which the technician functions, i.e., (1) research, design, or development; (2) production, operation, or control; (3) installation, or maintenance; (4) sales; or (5) supervision.

Technician Levels

The definition given above, being generic, permits application to all the areas of manufacture, but does not indicate levels of technology. To overcome this apparent shortcoming, additional definitions were used for technician levels. The definitions used here were originally proposed by Christy Murphy.[2] They are as follows.

The engineering technician is defined as a technician who works primarily in direct contact with creative engineering. He is usually capable of original design and of making educated decisions within his specialty, and he may or may not work under the direct supervision of an engineer on projects within his specialized field.

The industrial technician is defined as a technician whose specialty is closer to the production facilities of the industry than to the creative engineering function within the industry. His specialties are directed toward the intensely practical problems associated with the production capacities of the industry.

The technical specialist is defined as a highly specialized technician who has developed a skill or facility, the use of which constitutes his major occupational function. He is a highly competent performer at some particularly complex task. An example of the technical specialist is the technician who specializes in measurement and the use of complex measuring instruments.

PAST RESEARCH

The early studies were devoted to defining the term technician in order to develop criteria for classifying him. "What is a technician?" became a difficult question because the term was used to describe a tremendously wide range of individuals in diverse work situtations. It is evident that two criteria were used extensively: first, that of training and education; second and most generally, that of function and skill level.[3,4]

Subsequent studies clearly identified the fields in which technicians are found, with research, design, and development receiving greatest attention.[5,6] In these fields, the technicians generally act as direct support personnel for engineers and/or scientists. These studies permit the classification of technicians into occupational groups with similar requirements in terms of functions and skills.[7]

Most of the studies conducted to date in the area of technical education have included attempts to determine present and future manpower needs.[8,9] There have been, in addition, suggested curricula for specific technical occupations subjectively outlined on the basis of function, skill, and need.[10]

The more recent studies in technical education have focused upon specific course content in relation to one technical occupation group.[11] These have been necessitated by the diverse offerings and requirements in a given subject matter area among training programs purporting to serve identical functions.

A cursory examination of the curricula in various institutions throughout the country must result in the conclusion that the training programs for any specific technical occupation have little similarity.

Now that the basic terms, occupational groupings, and areas of need have been investigated it is time to identify more precisely the curricula content common to a variety of technical training programs.

PROBLEM

Through the years there have been many factors contributing to the need for research in vocational-technical education. The rapidly growing population, increasing school enrollments, rapid growth in the number of technical occupations, and the migration of industries are but a few of the crucial indicators. The advent of the "space age" and scientific developments since World War II have necessitated some rapid industrial changes. The electronics industry has experienced by far the most rapid change, resulting in unprecedented shortages of skilled manpower. The electronics industry was among the first to feel the need for technicians; others have followed.

Accurate information about jobs is needed to plan the educational programs involved in the recruitment, placement, training, employment and utilization of technicians. Recent research studies on job analyses and performance requirements have developed detailed listings of skills and functions. The U. S. Office of Education Study, Electrical and Electronics Technology,[12] has reported on how the basic occupational information resulting from a job analysis is used to determine the relationship between jobs and the skills and abilities required for successful job performance.

The translation of required skills and abilities into curriculum becomes a subjective matter in most cases. Information is needed which will more accurately define the curricula for the technical occupations. Technical education's present concern is only in part a result of the public pressure for more science and mathematics in the school curriculum; but, more important, it is due to the steady growth in breadth and depth of the need for technical education curricula in the public schools.

The problem at hand is to establish an empirical basis on which more accurate decisions concerning curriculum content in technical education can be made prior to the institution of training programs.

Vocational education has attempted to improve the functional relationship between the curriculum content and occupations by the use of advisory committees and follow-up studies of graduates. The current shortage of technicians and industry's preference for personnel trained in the armed forces serve as mute evidence that current and past processes of determining curriculum content are less than satisfactory. The approach used in this study is not typical of past activities in vocational-technical education. It is the hope of the author that the rethinking process which led to this report may contribute to the progress of curriculum development in the area of occupationally centered education.

SETTING

The distribution of manpower, current and predicted, by age group and occupational classification for the State of Illinois is very similar to that of the United States as a whole.[13] Illinois has been less affected by the growing concentrations of industry than many states. California has currently the largest concentration of electronics industries. Michigan has long been identified with the auto industry. The distribution of employees among the twenty-census categories for manufacture in Illinois approximates that of the U. S. as a whole with the exception of tobacco products, textile mill products, leather and leather products, and instruments and related products. Thus, a sample of Illinois industry would approximate that of the U. S. as a whole for 16 of the 20 census categories of manufactures.[14]

However, vocational-technical education offerings in Illinois are not representative of the U. S. as a whole. Though probably an overstatement, Frank Cassell (vice-president of Inland Steel) says that "vocational education in Illinois bears about the same relationship to the real needs of industry as the shovel and the pickax do to the equipment demands of road building."[15] At the time of this writing, all recommendations for revising vocational-technical education in Illinois have been to no avail.

GENERAL METHODOLOGY OF THE STUDY

One of the basic concerns of the project was to be as representative of the industries and their technicians as possible within the monetary and time limits of this study. To give representation, it was necessary to have randomly selected technicians from randomly selected industries. The selection process is described more fully in subsequent chapters.

The data collection was by structured interview and a card-sort technique. The development of these instruments is covered in detail in subsequent chapters and the instruments are included in the appendices.

FOOTNOTES

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12. Electrical and Electronics Technologies: Job Descriptions and Suggested Techniques for Determining Courses of Study in Vocational Education Programs, U. S. Office of Education, (Bull. OE 800004; Washington: Government Printing Office, 1960), p. 34.

13. Vocational and Technical Education in Illinois: Tomorrow's Challenge, Bureau of Education Research, College of Education, University of Illinois, Urbana, 1960, pp. 5-27.

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15. Frank Cassell as quoted in Time Magazine, p.42, September 6, 1963.

CHAPTER II

LOCATING THE TECHNICIANS

The universe of manufacturers used in this study was supplied by the Illinois Employment Security Division of the Illinois Department of Labor.* This list of manufacturers had the advantages of being (1) up to date (employers with four or more employees are required by law to be registered); (2) made up of establishments rather than companies; (3) on IBM cards which facilitated random selection; (4) combined with information, in addition to names, that was pertinent to the research concerns.

DEFINITIONS

The definitions used herein are consistent with those used by the Illinois Employment Security Administration, although the source cited may be other than Illinois laws or publications.

(1) Definition of establishment A definition of a manufacturing establishment is as follows.

> An establishment is an economic unit which produces goods or services. For example, a farm, a mine, a factory, a store. In most instances, the establishment is at a single physical location and is engaged in only one or predominantly one type of economic activity for which an industry code is applicable.[1]

This definition as used by the Illinois Department of Labor provides for inclusion of essentially all industries in the state except those organized as nonprofit organizations and public utilities.

---

*The author gratefully acknowledges the assistance of Elizabeth Slotkin and Samuel Bernstein of the Illinois Employment Security Division.

(2) Definition of Manufacturing

> The mechanical or chemical transformation of inorganic or organic substances into new products. The assembly of component parts or products is also considered to be manufacturing if the resulting product is neither a structure nor other fixed improvement. These activities are usually carried on in plants, factories, or mills, which characteristically use power-driven machines, and materials-handling equipment.[2]

(3) Definition of the Universe of Manufacturing Establishments

Establishments required to file reports with the state agency are:

> Any employing unit which has had four or more persons in employment in Illinois within each of 20 or more different calendar weeks in any calendar year is required to pay contributions for that calendar year and for at least the immediately following calendar year, even though it did not or does not have as many as four employees in any week in that second year.[3]

(4) Definition of Industrial Classifications Manufacturing classifications are as follows.

(20) food and kindred products

(21) tobacco manufacturers

(22) textile mill products

(23) apparel and other finished products made from fabrics and similar materials

(24) lumber and wood products except furniture

(25) furniture and fixtures

(26) paper and applied products

(27) printing, publishing, and allied industries

(28) chemical and allied products

(29) petroleum refining and allied industries

(30) rubber and miscellaneous plastic products

(31) leather and leather products

(32) stone, clay and glass products

(33) primary metal industries

(34) fabricated metal products except ordinance machinery and transportation equipment

(35) machinery except for electrical

(36) electrical machinery, equipment and supplies

(37) transportation equipment

(38) professional, scientific and controlling instruments, photographic, optical, watches and clocks

(39) miscellaneous manufacturing industries

The numbering above[4] is consistent with that used by the U. S. Census and the Illinois Employment Service.

SELECTING THE SAMPLE

The most recent listing available to the research project included a total of 14,764 manufacturing establishments in the state, of which 6,899 employed 20 or more persons. There was a total of 1,180,464 people employed in manufacturing in Illinois in March of 1962. 1,115,073 (or 94.5%) were employed by companies of 20 employees or more. Companies with fewer than 20 employees were excluded from the sample in order to maximize the inclusion of technical personnel.

A further breakdown of the industrial establishments by size is as follows.

1. 20-49 employees; there are 3,161 establishments employing 99,504 people.
2. 50-99 employees; there are 1,597 establishments employing 111,200 people.
3. 100-249 employees; there are 1,256 establishments employing 194,948 people.
4. 250-499 employees; there are 465 establishments employing 158,883 people.
5. 500-999 employees; there are 259 establishments employing 178,768 people.
6. 1000 employees or over; there are 159 establishments employing 371,770 people.

To obtain the random sample of 500 from the excess of 6,000 industries, every 13th industrial establishment was drawn. (This represents 7.6% of the establishments.) A random starting point was selected and every 13th industrial establishment thereafter was selected from an alphabetized listing. Each card was than duplicated and the originals returned to the files of the Employment Services Office and the duplicates taken for the sample of the research project. Matching cards with addresses were also supplied by the Illinois Employment Service.

The Sample Versus the Universe

Even though the research staff was confident that the sample selected was representative of the universe, it was deemed desirable to compare the two on three basic factors. (See Table II-1.) Chi-square

TABLE II-1

Distribution of Universe and Sample Among Manufacturing Categories

Manufacturing Per Census Code	Number of Establishments in Illinois	Number of Employees in Illinois	Number of Establishments in Sample	Number of Sample Establishments Employing Technicians	Number of Employees in Sample Establishments	Number of Employees in Sample Establishment with Technicians
20	1,721	124,987	60	6	6,372	1,255
21	3	351	0	0	0	0
22	86	7,083	5	1	1,116	667
23	769	41,414	30	0	2,826	0
24	435	11,350	10	1	478	57
25	513	27,925	16	3	3,102	2,188
26	447	37,962	21	6	4,769	1,928
27	2,103	100,856	54	3	6,497	996
28	749	52,294	26	11	4,834	2,610
29	99	12,624	5	1	551	106
30	363	28,272	13	3	1,244	519
31	166	18,213	7	1	861	67
32	701	37,072	18	2	1,616	221
33	527	99,945	26	13	10,930	9,895
34	1,955	126,086	65	20	6,027	3,364
35	2,123	195,142	59	19	6,662	4,703
36	832	175,242	40	17	8,912	5,102
37	235	36,684	11	0	723	0
38	331	35,812	11	5	1,089	804
39	691	33,446	23	6	2,269	557
	14,849	1,202,760	500	118	70,882	35,039

was used to asses the independence of the sample with the following results.

(1) The sample compared with the universe on distribution among manufacturing classifications:

$X^2 = 4.859$ df = 18 $P > .99$

Conclusion: Any difference between sample and universe can be ignored.

(2) The sample compared with the universe on distribution among standard metropolitan census areas:

$X^2 = 5.143$ df = 7 $.50 < P < .70$

Conclusion: Rockford, East St. Louis, Decatur, and the Quad-Cities areas were under represented, but not to the point of invalidating the sample.

(3) The sample compared to the universe on the size of the establishment (number of employees):

$X^2 = 13.811$ df = 18 $.70 < P < .80$

Conclusion: The sample is sufficiently representative of establishment size.

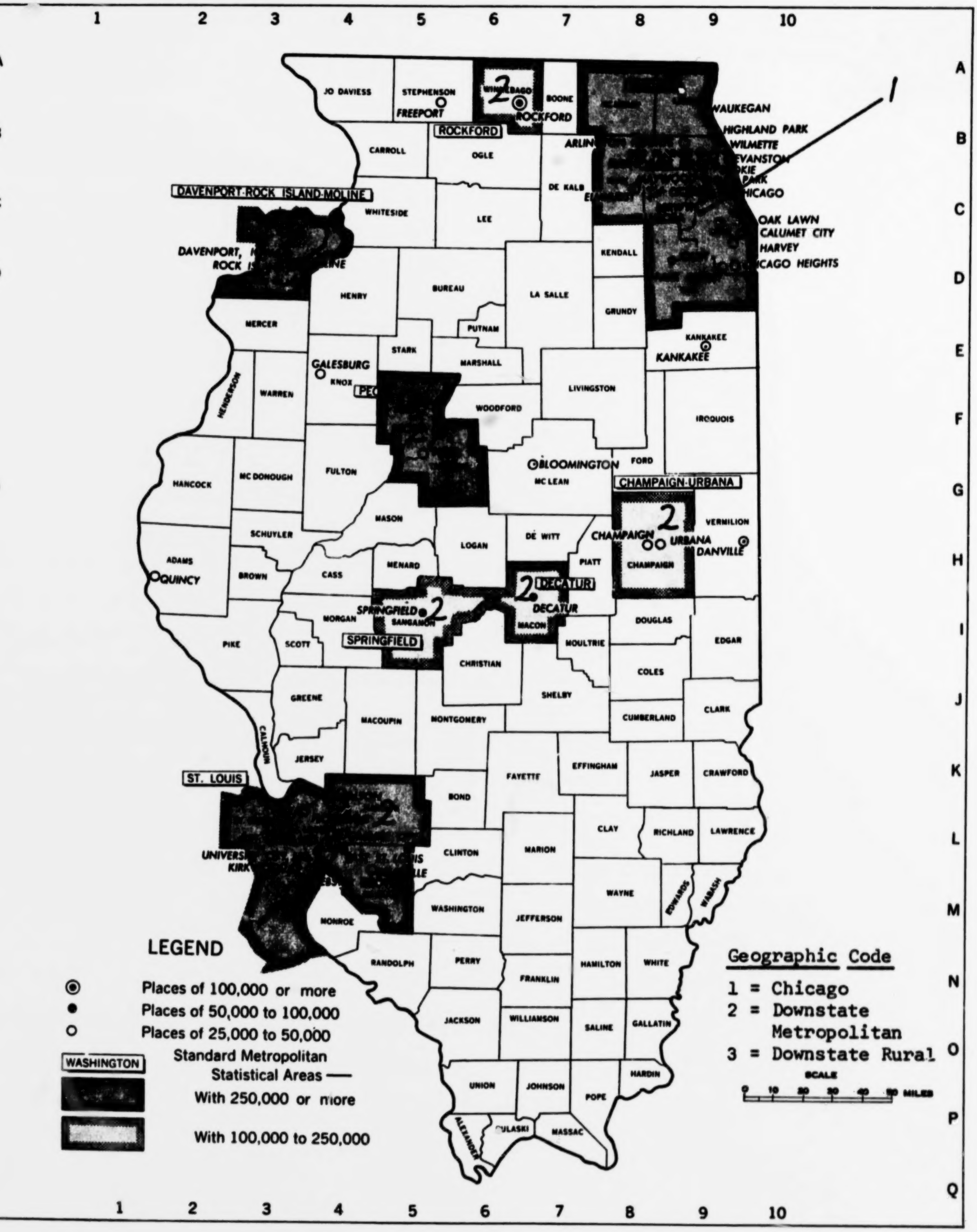
On the basis of the above it was concluded that the sample of manufacturing establishments was sufficiently representative of the universe as a whole. (Total number of employees represented by the sample was equal to 5.89% of the universe.)

Geographic Location, Size, and Area Manufacture

The sample was coded for geographic location (based on the Standard Metropolitan Statistical Areas): (1) Greater Chicago Area--McHenry, Lake, Kane, Dupage, Cook, Will; (2) Downstate Metropolitan--

FIGURE II-1

ILLINOIS—COUNTIES, PLACES OF 25,000 OR MORE, AND STANDARD METROPOLITAN STATISTICAL AREAS


1 2 3 4 5 6 7 8 9 10
A B C D E F G H I J K L M N O P Q
JO DAVIESS
STEPHENSON
FREEPORT
WINNEBAGO
ROCKFORD
BOONE
CARROLL
OGLE
DE KALB
WAUKEGAN
HIGHLAND PARK
WILMETTE
EVANSTON
CHICAGO
OAK LAWN
CALUMET CITY
HARVEY
CHICAGO HEIGHTS
ARLINGTON
ELMHURST
DAVENPORT-ROCK ISLAND-MOLINE
DAVENPORT
ROCK ISLAND
MOLINE
WHITESIDE
LEE
KENDALL
HENRY
BUREAU
LA SALLE
GRUNDY
MERCER
PUTNAM
STARK
MARSHALL
KANKAKEE
GALESBURG
KNOX
PEORIA
WARREN
HENDERSON
WOODFORD
LIVINGSTON
IROQUOIS
HANCOCK
MC DONOUGH
FULTON
BLOOMINGTON
MC LEAN
FORD
CHAMPAIGN-URBANA
MASON
SCHUYLER
LOGAN
DE WITT
CHAMPAIGN
URBANA
VERMILION
DANVILLE
ADAMS
QUINCY
BROWN
CASS
MENARD
PIATT
DECATUR
SPRINGFIELD
SANGAMON
MORGAN
MACON
DOUGLAS
EDGAR
PIKE
SCOTT
MOULTRIE
CHRISTIAN
COLES
GREENE
SHELBY
CLARK
MACOUPIN
MONTGOMERY
CUMBERLAND
CALHOUN
JERSEY
FAYETTE
EFFINGHAM
JASPER
CRAWFORD
ST. LOUIS
BOND
CLAY
RICHLAND
LAWRENCE
UNIVERSITY CITY
KIRKWOOD
EAST ST. LOUIS
BELLEVILLE
CLINTON
MARION
WAYNE
EDWARDS
WABASH
WASHINGTON
JEFFERSON
MONROE
RANDOLPH
PERRY
FRANKLIN
HAMILTON
WHITE
JACKSON
WILLIAMSON
SALINE
GALLATIN
HARDIN
UNION
JOHNSON
POPE
ALEXANDER
PULASKI
MASSAC
1
2
2
2
2
2
2
LEGEND
◉ Places of 100,000 or more
● Places of 50,000 to 100,000
○ Places of 25,000 to 50,000
WASHINGTON Standard Metropolitan Statistical Areas —
With 250,000 or more
With 100,000 to 250,000
Geographic Code
1 = Chicago
2 = Downstate Metropolitan
3 = Downstate Rural
SCALE
0 10 20 30 40 50 MILES

Winnebago, Rock Island, Scott, Peoria, Tazewell, Sangamon, Macon, Champaign, Madison, St. Clair; (3) Downstate Rural--all others. (See Figure 1.)

To test the independence of the three measures above (geographic area, type of manufacture, and size) the Chi-square technique was employed with the following results.

Geographic Location compared with Type of Manufacture

$X^2 = 49.57$ df = 36 $.02 > P > .01$

Geographic Location compared with Size (total number of employees)

$X^2 = 9.43$ df = 8 $.50 > P > .30$

Type of Manufacture compared with Size

$X^2 = 71.78$ df = 72 $.80 > P > .50$

From this analysis, it was necessarily concluded that the type of manufacture is related to the geographic area but is not related to the size of the establishment, nor is there a significant relationship between the geographic location within the state and the size of the establishment.

Inspection of the internal distribution of the Chi-square matrices indicates that transportation equipment and leather and leather products exceed the statistically expected frequencies for downstate rural locations; printing, publishing and applied products plus food and kindred products exceed the statistically expected frequency for the downstate metropolitan areas.

THE SHAKEDOWN

After establishing the industrial universe and selecting the random sample, it was necessary to shake down the sample. The shakedown consisted of personal contacts and interviews with the management of each of the establishments in order to determine whether or not they employed technical workers as per the project definition. As the result of these initial interviews, the sample was divided into two categories: those confirmed, and those being rejected. The rejected manufacturing establishments were rejected on the basis that they did not employ technical workers as per the definition. On the other hand, those establishments designated as confirmed did employ one or more technicians by the project definition.

The task of determining which manufacturing establishments would be rejected or confirmed was not as simple as it may seem. First, in order not to bias the original sample, it was necessary that all contacts be made on the assumption that each firm, if they employed technicians, would be included in the study. This meant that none of the installations could be offered the alternative of not participating. Needless to say, this required more than one contact, telephone calls, and further correspondence before it could be ascertained whether or not the given firm employed technical workers.

Since the term "technician" or "technical worker" means many things to many people, it was necessary that each of the interviewers pursue the question "Do you employ technical workers?" to the point that it was satisfactorily established that the final decision was made in terms of the function of the worker and not on the basis of job title or occupational designation as per the employing establishment. As a result of this intensive interviewing, the research staff was confident that each of the installations designated as confirmed did employ people functioning at the level specified in our original definition and that those establishments rejected did not employ people functioning in the technician capacity. In the process it was determined that 118 of the 500 establishments employed technicians.

Selecting the Interviewees

The study was designed to retain the representativeness without overburdening selected industrial installations. The participating industrial establishments were requested to permit the research staff to interview a small portion of the employees who fell within the occupational classifications previously described. In recognition of the obvious fact that technicians perform a variety of functions a concerted attempt was made to get at least one interviewee from each technician classification at each establishment. A scale for determining the number of technicians to be interviewed was developed (see Form A in Appendix A) whereby as the total number of technicians employed at a given establishment increased the number to be drawn at random to be interviewed increased, but in a linear fashion. It was assumed that if an establishment had, for example, 41 to 50 technicians a random sample of 12 would cover the various job functions that the entire group performed. In the process of interviewing, this assumption proved to be well founded.

In the manner described above 348 technicians were selected and interviewed at 113 industrial establishments throughout Illinois. Five establishments employing a total of 19 technicians refused to permit interviews.

Identifying the Technician

The initial contacts to identify the companies that did employ technicians were by and large very accurate. The surprising aspect of the second visit was the lack of information at the disposal of management, including personnel managers and chief engineers. It was to be expected that definition of technician used herein differs from the definition of technician held by management of the various establishments. On the first contact management indicated the number of technicians (according to the project definition) they had in their employ, keeping in mind that those who possessed a baccalaureate degree were not to be included in our technician ranks. On the second visit, to interview technicians, it was not uncommon to discover that management, personnel managers, chief engineers, did not know the educational background of their employees. There were instances when the chief engineer was surprised to find someone working with him as an assistant engineer (or some such title) who had a baccalaureate degree. It was also surprising to find that they had very little knowledge about the actual job function being performed by technicians. They would read our definition, conclude that, for example, they had 15 technicians that would fit our definition and they would proceed to describe the kinds of functions they were performing for the company. When the conversation was pressed further, which may have included a tour of the plant, and eventually conversation with the technicians, management, personnel managers, and the chief engineers were again surprised to find out exactly what their employees were doing from day to day. This again modified a number of technicians in the employ of the individual companies as per our definition.

The fact that management, personnel managers, chief engineers were not able to specify job functions being performed by individuals is rather startling. The fact that they were unable to tell without looking at the personnel files whether a man had a degree is in some respects rather satisfying. College degrees are of more and more import in gaining employment. But this lack of information about who has degrees once they are in the employ of industry seems to imply that the degree in itself does not insure continuity in employment and it is job performance and job function that dictates continued employment and undoubtedly pay raises and other advancements. The lack of information, on the part of management, about the background and job functions of technicians supports one of the basic tenets of this research, "To find out what a technician does and what knowledges are related to his job, the place to go is to the employed technician." It also supports the discussion on the subject of education and technical employment by Brady[5] and Hansen.[6]

Rejects Versus Confirms

The relationships investigated previously were repeated by reject and confirm categories to test the independence of these two categories by manufacturing area, geographic location, and size. Contrary to the research staff's expectations, there appear to be no relationships between the reject and confirm categories and the geographic location of the manufacturing establishment. The frequencies involved here result in a Chi-square of 2.66 with 2 df. The result was a probability less than .30 and greater than .20 and it was therefore concluded that the reject and confirm categories were independent of geographic location.

As would be expected the greater the number of employees at a given establishment the more likely it was that there were technicians employed. This was assumed in the selection of the sample when establishments with less than 20 employees were deleted from the universe before the random sample was selected.

Manufacturing area was also related to the reject and confirm categories, with the frequency here yielding a Chi-square of 62.28, with 18 df and a probability of less than .001. (See Table II-2 below.) The types of manufactures that exceeded the expectations in the reject

TABLE II-2

Distribution of Reject and Confirms Among Manufacturing Area

Mfg. Area	Confirms			Rejects			Total
20	0 = 6	E = 14.16	X^2 = 4.70	0 = 54	E = 45.84	X^2 = 1.44	60
22	0 = 1	E = 1.18	X^2 = .03	0 = 4	E = 3.82	X^2 = .01	5
23	0 = 0	E = 7.08	X^2 = 7.08	0 = 30	E = 22.92	X^2 = 2.19	30
24	0 = 1	E = 2.36	X^2 = .78	0 = 9	E = 7.64	X^2 = .24	10
25	0 = 3	E = 3.78	X^2 = .16	0 = 13	E = 12.22	X^2 = .05	16
26	0 = 6	E = 4.96	X^2 = .22	0 = 15	E = 16.04	X^2 = .07	21
27	0 = 3	E = 12.74	X^2 = 7.45	0 = 51	E = 41.26	X^2 = 2.30	54
28	0 = 11	E = 6.14	X^2 = 3.85	0 = 15	E = 19.86	X^2 = 1.19	26
29	0 = 1	E = 1.18	X^2 = .03	0 = 4	E = 3.82	X^2 = .01	5
30	0 = 3	E = 3.07	X^2 = .00	0 = 10	E = 9.93	X^2 = .00	13
31	0 = 1	E = 1.65	X^2 = .25	0 = 6	E = 5.35	X^2 = .08	7
32	0 = 2	E = 4.25	X^2 = 1.19	0 = 16	E = 13.75	X^2 = .37	18
33	0 = 13	E = 6.14	X^2 = 7.66	0 = 13	E = 19.86	X^2 = 2.37	26
34	0 = 20	E = 15.58	X^2 = 1.25	0 = 45	E = 50.42	X^2 = .58	66
35	0 = 19	E = 13.92	X^2 = 1.85	0 = 40	E = 45.08	X^2 = .57	59
36	0 = 17	E = 9.44	X^2 = 6.05	0 = 23	E = 30.56	X^2 = 1.87	40
37	0 = 0	E = 2.60	X^2 = 2.60	0 = 11	E = 8.40	X^2 = .80	11
38	0 = 5	E = 2.60	X^2 = 2.22	0 = 6	E = 8.40	X^2 = .69	11
39	0 = 6	E = 5.43	X^2 = .06	0 = 17	E = 17.57	X^2 = .02	23
Total	118			382			500

$X^2 = 62.28$ df = 18 $P < .001$

category were transportation equipment, printing, publishing and allied products, apparel and similar products, and food and kindred products. The types of manufactures that exceeded the statistical expectation in the confirmed category were (26) paper and applied products, (28) chemical and applied products, (33) primary metals, (34) fabricated metals, (35) non electrical machinery, (36) electrical machinery, (38) professional, scientific and control instruments. It is apparent that the aforementioned relationship between size and types of manufacture was also operating in the case of the reject and confirm categories.

The presence of technicians in some types of manufacture and the absence of them in others may be the result of rather routine functions in manufacture with little production planning and research, such as in apparel and similar products. There are some, however, that currently tend to not employ technicians that are in the process of modifying their production procedures from batch operations to continuous operations, which will undoubtedly increase the probability of technicians being employed. This is particularly true of food and kindred products.

FOOTNOTES

1. Standard Classification Manual, Executive Office of the President, Bureau of the Budget, 1957.

2. U. S. Census of Manufactures: 1958 Area Statistics, U. S. Bureau of Census, Vol. III, p. 12.

3. Illinois Unemployment Compensation Act, (Department of Labor), State of Illinois, Publication UC-200, revised 11/61, p. 5.

4. Standard Classification Manual, Executive Office of the President, Bureau of the Budget, 1957.

5. James T. Brady,et.al., "Close-Up of the Technician, Engineering Semi-Pro?" Machine Design, May 12, 1960.

6. W. L. Hansen, "Total and Private Rates of Return to Investment in Schooling," Journal of Political Economy, Vol. 61, pp. 128-140, April, 1963.

CHAPTER III

DESIGN AND FUNCTION OF THE INSTRUMENTS

The basic instrument used in this study to collect data on the knowledges related to technical occupations was a modified version of the Q-sort technique. The modifications were sufficiently comprehensive to dictate referring to the instrument as a card sort.

A group of cards was developed to represent the content of courses taken by technicians in preparation for their various jobs. Each card has a brief description of a course. This description was developed to approximate the course content of most post high school technical institutes. The cards for the card sort were developed by abstracting course descriptions from approximately 100 public, private, and military technical institute catalogs. By this method over 250 cards were originally developed. These cards were then inspected and duplicates were removed. Overlapping course descriptions were modified to provide a synthesis which would enable each card to have the description of a course that was sufficiently specific so as not to overlap a wide variety of knowledges.

The current emphasis upon degrees in the post high school public technical institutions suggests that legislatures and other agencies influence curriculum content for technicians. This is definitely the case when an AA degree is awarded. The general requirements are stipulated by law and sometimes expanded by local school district action.

These generally include the social sciences and English requirements necessary for intelligent participation in our democratic society. Therefore, these areas are eliminated from the card sort since the card sort was conceived as an instrument to define the areas of knowledge functionally related to job performance over which the school administrator has jurisdiction and/or the technician has the option of selecting courses.

After the removal of duplicate descriptions and the synthesis of overlapping descriptions the result was a deck of 90 cards which seemed to the research staff to sufficiently sample the kinds of knowledges that could conceivably be functionally related to the whole spectrum of technical occupations. At this point the card sort was administered to a panel of experts each of whom was requested to identify those cards that described course content functionally related to the technology with which he was concerned. The panel of experts, all of whom were in the employ of the University of Illinois either as faculty members or research associates, included persons in mathematics, physics, chemistry, microbiology, engineering, graphics, electronics, labor and industrial relations, and business management. When an expert had identified those cards that were related to the technology he represented, he was then asked to inspect them for coverage and identify (1) areas in which cards were lacking, (2) contradictory or overlapping descriptions, and (3) the accuracy of each statement and its understandability.

By this means numerous modifications and changes were made and the number of cards expanded to 97.

At this point eight graduate students with knowledge of fluid power technology were asked to sort the cards on the basis of requirements needed to be successfully employed as a fluid power technician. When this was done, their comments were solicited in the same fashion as those from the panel of experts. Their responses were then analyzed by rank order correlation and coefficient of concordance techniques which resulted in a mean correlation of .73 and a coefficient of concordance sufficiently large to be significant at the one percent level.

The basic contribution of the comments of the eight graduate students was to modify the directions for the card sort to permit the initial distribution to be into three piles rather than the two initially suggested. These three piles were those cards which were (1) closely related to job performance, (2) somewhat related to job performance, and (3) totally unrelated to job performance as a technician.

At this juncture the card sort was administered to employed technicians in three pilot studies. The pilot studies will be discussed in more detail later in this chapter.

The use of the card sort technique in the interviewing process to solicit the respondent's opinion regarding the kinds of knowledge functionally related to his present position is a rather unique application of this technique. The Q-technique has been used by Morsh,[1] Schill,[2] and others as an assessment of group opinion; however, in this application the materials covered do not form a single continuum but are a composit of a variety of areas of knowledge and, as a consequence, the analysis is not the typical Q-correlation analysis.

The technique of having individuals respond to cards has a number of advantages over the rating form which is more typically used in a study of this kind. The most obvious advantages are (1) the opportunity to compare all of the items on the cards with each other in the process of responding, and (2) to make assessments of the relatedness of the material without committing oneself to a given response as would be the case in a rating scale. This permits further modifications and adjustments as the respondent proceeds through the process. It is not until the respondent is totally satisfied with the distribution of the cards that he commits himself.

In the desire and need to cover a broad range of knowledge it was impossible to have discreet statements on each card. As a consequence, it is rather hard, if not impossible, to be sure what specific statement on each card the technicians are responding to. This shortcoming is not sufficient to detract from the overall use of the card sort because it did permit an assessment of a broad range of knowledges and each card, though not discreet, was limited to a specific area of knowledge. Many times during the administration of the card sort and the recording of the responses, the interviewers had reason to question the placement of cards and invariably when the technician was asked why he selected a given card as being somewhere in the related section of the sort the reasons were valid and easily understood. At other times, without questioning the technician but taking time after completion of the interview to tour the facility and look at the work station and the kind of activities the technician was involved in, the questionable knowledges could be seen as being readily related to the job function.

The original concept of using a card sort for defining the curricula content functionally related to occupational needs in a variety of technologies remains valid. However, because of the scope of the occupations covered in the project there was a need to modify some of the basic techniques in the card sort.

In order to cover the wide variety of areas of knowledge which could conceivably be applicable to the various occupations, the numb of cards that were totally unrelated to any specific occupation was equal to approximately 40 of the 99 cards. This made it impossible for the respondents to distribute the unrelated cards in the right hand tail of the forced sort in a meaningful fashion since all were equally and totally unrelated.

In a typical card sort the respondent goes through the cards once and sorts them roughly into two or more categories which is followed by forced distribution. In the modified version of the card sort used in this project, the respondent sorted the cards into three categories.

This is called a rough sort. These were recorded prior to the following forced sort. (See Form B in Appendix A.) On the forced sort a basic modification was that the respondent was asked to distribute his related and somewhat related cards into the left hand tail of the forced distribution, and to inspect the unrelated pile to be sure no functionally related or somewhat related card had been overlooked. In recognition of the total unrelatedness of the third category of cards in the unforced sort, they were treated as being equal and were not forced into the normal distribution. (See Form C in Appendix A.)

As a consequence of this modification in the card sort, the typical Q-sort correlational analysis was not fitting because of the lack of normal distribution; the distribution having been consistently and greatly skewed to the left. The analytic techniques used are discussed in later chapters where the card sort data are presented.

Interview Format

The function of the personal interview was to permit the identification of major factors which could have influence upon the distribution of the cards in the card sort. It is for this reason that data were collected on occupational history, educational attainment, and current position in addition to the rather standard personal information regarding age, sex, race, and place of birth.

Since the card sort was a response to the current position, it was necessary to establish the length of time in the current position, the functions performed by the respondent, the responsibility exercised and the level of employment. In addition to an open ended description of the respondent's job function, data were collected on (1) the geographic location of employment, (2) the number of months in his current position, (3) his current salary, (4) the reason the respondent found employment in his current capacity, (5) whether or not he was placed in the position through the services of the Illinois State Employment Service, (6) the area of manufacturing as per the census coding for the establishment in which he was employed, and (7) the direction of his mobility from his previous job.

From the open ended description of the job functions the respondent's present job was classified by level of employment in the nine step code used by census with the intent that all of the respondents should fall within the technician category. It should be noted that the technician category was inserted between the skilled and the professional categories which is consistent with the definition of technician used in this study. Job functions were also coded in terms of the major area of responsibility. They are: (1) research and development, (2) sales, (3) production, or (4) maintenance. The open ended responses were further categorized in terms of type of activity engaged in. They were coded as: (1) engineering technicians or being predominantly concerned with abstractions in their everyday work activity, (2) industrial technicians were conceived to be primarily responsible for customizing a product or preparing prototypes prior to production, (3) technical specialists, or a person who is engaged in repetitive technical operations such as testing, quality control, and the like, and (4) supervision.

Similar information was collected for each of the jobs held by the respondent from the first full time position to present. The function of this information was to permit the categorization of the respondent in terms of a paradigm developed by Schill[3] for assessing job success via mobility patterns. Salary information from previous jobs was used as a verifying measure of mobility assessments made by the interviewers.

Data were collected on educational activities of the respondent. These data included high school education and all post high school educational experiences including public, private, military, company, correspondence, and non-supervised study. From the educational history the interviewers assessed the educational attainment in equivalent semester hours beyond high school. The function of this was to permit the assessment of the card sort dependent upon educational attainment of the respondent.

As has been mentioned before, data were also collected on the establishment in which the technicians were employed. The data consisted mainly of geographic location, total number of employees, total number of technicians employed, and the area of manufacture.

There is considerable literature to verify the importance of career patterns in the assessment of an individual's efficiency in the industrial setting. Project TALENT[4] has noted the changing aspiration through time of young men leaving the educational setting and going to work with the conclusion that as they move from education into the industrial setting and from the initial job to subsequent jobs their career choices become more realistic in terms of their abilities, experiences, and education.

Barry & Wolf in their recent Epitaph of Vocational Guidance[5] have concluded that career pattern analysis is by far the most promising of various methodologies used in vocational guidance. This is predicated on the work of men like Super,[6] Lipset and Bendix,[7] Miller and Form.[8]

In the interviewing process there are subjective qualities that cannot be ignored in the formulation of research, and the recording and analysis of data. The face to face contact and the open ended and often unsolicited responses contribute to the insights of the interviewer. In addition to this, it was very common in the conduct of this research to have a tour of the facility and an inspection of the production parts, the general working environment, the management structure, and the union structure of the establishment. These things could not help but give the author increased insights and sensitivity that enhance the data analysis.

The Pilot Studies

Three pilot studies were conducted to assess the instruments and the amount of time required for the interviewing process. In the three pilot studies a total of 28 technicians were interviewed that covered the widest possible range of technical occupations. The first pilot study was conducted as NASA in Huntsville, Alabama.* The other two were conducted in Illinois manufacturing establishments. As the result of the three pilot studies, two cards were added to the card sort raising the number of cards to 99 and the interview format was streamlined considerably to establish an interviewing time of about 25 minutes. During the three pilot studies a coding system was also developed to permit the coding of responses during the interviewing process rather than recording all of the data for coding at a later time. All of the codes (see Forms D & E in Appendix A) were left open ended where necessary so that they could be expanded in case responses during the study did not fall into the established categories. The only area in which the established coded responses were not sufficiently broad was in "Reason for Taking Job" and this continued to expand throughout the study.

Perhaps the most important single thing to come out of the pilot studies was the development of coded responses for questions concerning salaries at the various jobs throughout the respondent's job history. It came to the attention of the interviewers that respondents were hesitant to cite their salary in dollars per week and as the consequence, a card was developed (see Form F in Appendix A) that had the salary range on it with a code number whereby the respondent could indicate the bracket into which his salary fell by picking the appropriate code number from 01-21. This proved to be very advantageous in subsequent interviews and removed the hesitancy that the respondents had manifested during the pilot studies.

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*The author gratefully acknowledges the assistance of Marion Kent, Administrative Assistant, Marshall Spaceflight Center.

Keypunching the Data

The coding system described above admitted the data to be keypunched immediately upon return to the project office without necessitating that the keypuncher be involved in the interpretation of coding of the technicians responses. By this method the keypunching and verification kept pace with the data collection.

Administration of the Instruments

The identification of the technicians employed and the subsequent selection of those to be interviewed was a cooperative effort between the interviewer and management representative with the interviewer assuring himself that representativeness was achieved. In most cases the interviews took place in an office removed from the working and supervisory setting and was conducted on a one to one basis. In instances where 10 or 12 technicians were to be interviewed as many as four interviewers participated which permitted the process to be completed without unduely disturbing management or permitting time to elapse which would enable the technicians to feed back to their colleagues the details of the process.

FOOTNOTES

1. Joseph E. Morsh, "The Q-Sort Technique as a Group Measure," *Educational and Psychological Measurements*, Vol. XV, No. 4, pp. 390-95, Winter, 1955.

2. William John Schill, "The Use of the Q-Technique in Determining Curriculum Content," *California Journal of Educational Research*, Vol. XII, No. 4, pp. 178-184, September, 1961.

3. William John Schill, "Education and Occupational Success, "*Personnel and Guidance Journal*, pp. 442-444, January, 1963.

4. John C. Flanagan, et. al., *The American High School Student*, Technical Report to the U. S. Office of Education, Cooperative Research Project No. 635; Project TALENT Office, University of Pittsburgh, 1964, pp. 14-4.

5. Ruth Barry and Beverly Wolf, *Epitaph of Vocational Guidance*, Teachers College, Columbia University, (New York: Bureau of Publications, 1962).

6. Donald E. Super, *The Psychology of Careers*, (New York: Harper & Brothers, 1957).

7. Seymour Martin Lipset and Reinhard Bendix, *Social Mobility in Industrial Society*, (Berkeley and Los Angeles: University of California Press, 1959), pp. 14-17.

8. Delbert C. Miller and William H. Form, "Occupational Career Patterns as a Sociological Instrument," *American Journal of Sociology*, Vol. LIV, No. 4, p. 327, January, 1949.

CHAPTER IV

TECHNICIANS IN ILLINOIS INDUSTRY

Illinois industry is anything but stagnant. It is a fast moving, progressive series of business ventures. The food processing industry, for example, is currently in the throes of changing from batch to continuous process. In many respects the food processing industry is following a pattern already established by the chemical processing industries with increased reliance on control systems in the manufacturing process. The chemical industry, however, is more closely allied to the application of the sciences to the field of production. A multitude of products have been created by the chemical industry and they have really just begun. There is no limit to what they can accomplish with the raw material of the molecule as their basis for production. The food processing and the chemical industry are not totally independent since many of the chemical products come from the by-products of packing and food processing industries.

The metal working industries, both primary metal and fabricated metal, are also in the state of transition. The metal working industry is moving from man controlled machines to tape and computer controlled machines for producing fabricated metal products. While this is going on in the fabricated metal industries, the primary metal industries are moving from the open hearth to the oxygen lance and continuous casting processes, again closely dependent upon control systems for economical production.

One of the industries that is responsible for facilitating most of the dramatic changes in the aforementioned food processing, chemical, metal fabricating, and primary metals industry is the electronics industry since it was the genesis of control systems, computers, and punched taped reading devices. The major commitment of the electronics industry in Illinois has been to try to improve consumer products, primarily radios and televisions. Integrated circuits, a step beyond transistor technology, and miniturization of components, is forcing upon the Illinois electronics industries some drastic modifications. Whereas most of the research and development in electronics industries has in the past been allied to the defense and space concerns of the nation, this new development in electronics is creating a greater need for research development in the consumer allied electronics industry.

Although the above mentioned manufacturing categories are the ones that are experiencing the greatest change currently, change is by no means limited to them alone. Petroleum refining and allied industries are experiencing change as are the industries concerned with the production of professional and scientific control instruments, photographic instruments, optical instruments and watches. The changes are not as dramatic as yet.

The point has been reached where the production of capital outlay items required by advancing technology no longer requires manpower in a quantity sufficient to replace the workers displaced by automation and advancing technology. It goes without saying that advancing technology will decrease the need for production workers. It can easily be assumed also that advancing technology will increase the demand for technicians. The increasing inter-relationship between the disciplines upon which technology is based can be expected to dictate that the technicians have command of the abstractions from a variety of disciplines.

The function of this chapter is to analyze the personal variables of the respondents so as to isolate those variables or combinations of variables that have an effect upon the responses to the card sort. This would permit a logical and systematic analysis of the knowledges functionally related to a variety of technicians employed throughout the manufacturing establishments of the state of Illinois. Some of the data presented are included to enhance the understanding of who the technicians are and how they acquired their positions as technicians in Illinois manufacturing.

The method by which the technicians were identified and selected seems to justify the assumption that they are representative of technicians in Illinois manufacture as a whole. To give a clearer picture of the number of technicians in the state as a whole, the technicians identified during the interview were used as a base to extrapolate to the universe of manufacturing establishments. This data is presented in Table IV-1.

The formula used to extrapolate from the sample to the universe was:

$$\begin{array}{l}\text{Technicians}\\ \text{Employed in}\\ \text{Illinois}\\ \text{Manufacturing}\end{array} = \Sigma \; \frac{\begin{array}{l}\text{number of technicians in}\\ \text{each mfg. area employed by}\\ \text{establishment in the sample}\end{array}}{\begin{array}{l}\text{number of employees in the}\\ \text{establishments in the sample}\\ \text{for each mfg. area}\end{array}} \; \text{X} \; \begin{array}{l}\text{Total}\\ \text{number of}\\ \text{employees}\\ \text{in each}\\ \text{mfg. area}\end{array}$$

TABLE IV-1

Technicians Employed by Manufacturing Category

Mfg. Code	Tech. Employed in Sample	Tech. Interviewed in Sample	Extrapolation of Tech. Employed to the Universe
20	36	24	706
21	0	0	000
22	2	1	13
23	0	0	000
24	1	1	24
25	25	10	225
26	43	18	342
27	10	5	55
28	76	38	822
29	4	4	92
30	5	4	114
31	1	1	21
32	3	3	69
33	119	47	1088
34	67	40	1402
35	138	68	4042
36	79	53	1553
37	0	0	000
38	79	21	2598
39	19	10	280
Totals	707	348	13,446

Variables with Poisson Distribution

Three items, race, sex, and access to the state employment service, were found to have the preponderance of response in one category.

Race

There were six respondents who were Negro, and three who were other non-white for a total of nine non-white respondents. This is 2.6% of the total sample of technicians. Contrasting this with the total male adult population 20 years and over in Illinois, we find that the non-whites make up 9.42% of this segment of our population; consequently, it must be recognized that the non-white population in Illinois is under represented in the technician ranks.[1] If race could have an effect upon the other data collected, the N in this case is sufficiently small so that the effect can be ignored.

Sex

There was no need to ask the respondents questions on sex; hence, the male and female categories were recorded without their knowledge. There were five female technicians in the sample. This is 1.3% of the total number of respondents; consequently, there is no discussion of the relationship between sex and other variables in this report since the N was too small to have any appreciable effect on the other variables.

State Employment Service

Expecting that a significant proportion of the respondents would have availed themselves of the service of a state employment service sometime during their occupational career, one of the questions asked of each of the respondents in relation to each of his jobs in his job history was whether or not he had been referred to that job through the State Employment Service. His responses were coded to indicate if he was not placed, if he was placed, and if he was tested in the process of placing. Of 1,404 jobs represented by the occupational histories of the respondents 252 were intra-establishment job changes; the remaining 1,152 jobs represent changes from one establishment to another.

The State Employment Services had referred the respondents to 41 of these jobs or 3.55% of all jobs held. Ten of the technicians in the sample or 2.87% had been referred to their current position through the State Employment Service. Only three of the respondents had ever taken the GATB in the process of State Employment Service referral.

Reasons for Taking Jobs

Occupational mobility was an area of investigation to which the project was committed as part of the assessment of job success on the current job. Earlier in the pilot studies it became apparent that the respondents, in the process of assessing the relative merit of a given job with the job immediately preceding it, volunteered a prime reason for the change which was often in addition to the internal job functions. The research staff decided to record these reasons. This remained an open ended question although the responses were categorized. Every time a response that hadn't been categorized previously was solicited from a technician it was given a new code number and the categories were allowed to expand.

Upon analysis of the reasons for taking jobs by job level and by the sequence in the job careers it was possible to collapse all of the reasons given into six basic categories. These categories being

(1) personal reasons such as convenience, close to home, wife's preference for an area to live, and working conditions more to the liking of the individual

(2) financial considerations, basically money, with an occasional response relating to security

(3) the opportunity for additional responsibility, higher status or opportunity for advancement

(4) opportunity to gain experience and/or training in the occupation of particular interest to the respondent

(5) the personal influence of an individual either friend, family, or teacher

(6) all other reasons such as a cutback in employment at the previous location, personality conflicts with immediate supervisors, or hesitance to identify a reason for changing jobs.

As can be seen by inspecting the internal distributions of Table IV-2, there is no change of any significance in categories four and six, while there is a general decline in categories one, two, and five which are respectively personal reasons, expectations in the financial realm,

TABLE IV-2

Distribution of Reasons for Taking Each Position

Reasons by Category

Jobs	1	2	3	4	5	6	Total
7&8	0 = 6 E = 5.2 X^2= .12	0 = 5 E = 6.2 X^2= .23	0 = 9 E = 8.1 X^2= .15	0 = 6 E = 7.9 X^2= .46	0 = 3. E = 3.3 X^2= .03	0 = 6 E = 4.3 X^2= .68	35
6	0 = 5 E = 6.8 X^2= .32	0 = 10 E = 8.2 X^2= .40	0 = 11 E = 10.6 X^2= .01	0 = 8 E = 10.3 X^2= .51	0 = 6 E = 4.3 X^2= .68	0 = 6 E = 5.0 X^2= .20	46
5	0 = 17 E = 11.6 X^2= 2.53	0 = 19 E = 13.8 X^2= 1.96	0 = 18 E = 18 X^2= 0	0 = 9 E = 17.5 X^2= 4.15	0 = 3 E = 7.3 X^2= 2.55	0 = 12 E = 9.6 X^2= .60	78
4	0 = 11 E = 17.6 X^2= 2.41	0 = 23 E = 21 X^2= .19	0 = 34 E = 27.2 X^2= 1.70	0 = 24 E = 27.5 X^2= .71	0 = 6 E = 11.2 X^2= 3.43	0 = 21 E = 13.5 X^2= 4.15	119
3	0 = 24 E = 26.0 X^2= .15	0 = 35 E = 32.7 X^2= .16	0 = 48 E = 42.5 X^2= .72	0 = 42 E = 41.5 X^2= 0	0 = 17 E = 17.4 X^2= .02	0 = 19 E = 23.9 X^2= 1.0	185
2	0 = 41 E = 40 X^2= .02	0 = 55 E = 48 X^2= .75	0 = 42 E = 62 X^2= 6.46	0 = 62 E = 60.5 X^2= .04	0 = 33 E = 25.4 X^2= 2.27	0 = 37 E = 33.1 X^2= .49	270
1	0 = 75 E = 51.5 X^2= 10.8	0 = 74 E = 61.2 X^2= 2.5	0 = 12 E = 80 X^2= 57.9	0 = 88 E = 77.5 X^2= 1.18	0 = 91 E = 32.5 X^2=105	0 = 8 E = 42.1 X^2= 28	348
current	0 = 28 E = 47.6 X^2= 8.1	0 = 31 E = 57 X^2= 11.9	0 =150 E = 74 X^2= 74	0 = 77 E = 72 X^2= .22	0 = 14 E = 30.3 X^2= 8.15	0 = 23 E = 40.1 X^2= 7.3	323
totals	207	252	324	316	173	132	1404

X^2 = 343.32   df = 35   P < .001

and a very decided drop in influence of families and friends in job selection.

There is a tremendous increase from the first job through the current job in the quest for responsibility, status, and opportunity for advancement.

A word of explanation about the distribution of the respondents by job number is in order. There are 348 responses for job number 1 which would be the initial job of the respondent and 323 responses for the current job. The reason for this being that 25 of the technicians interviewed were employed for the first time and for this analysis their current job was placed in the first job category because there had been no opportunity for them to manifest any change in reason for accepting a job. The total N in the following table of 1,404 represents the total number of jobs held by all of the respondents interviewed during the project.

The significance of the Chi-square reported in Table IV-2 demonstrates beyond much doubt that the reasons given for accepting a job are dependent upon where the job falls in the occupational career; the greatest contrast was between the first job held and the current job. The trends mentioned in the paragraph above are substantiated by the contribution of the cells to the total Chi-square with the greatest change again occurring in the category of personal influence with a drastic decrease in personal influence from the first job to the current job. This is consistent with the theoretical models of career patterns proposed by

Miller and Form[2], Lipset and Bendix[3], Caplow[4], and other sociologists who have studied occupational career patterns. The data presented here are sufficiently strong to substantiate the concept of a trial period followed by a more stable work pattern. The findings are not shocking in that the reasons for accepting positions can logically be explained and are consistent with maturity on the part of the respondents during their occupational career. It is not surprising that young men rely rather heavily upon the influence of friends and family to gain their first position. Nor is it surprising that money is one of the major considerations in accepting the job. The trend toward being more concerned for status, responsibility and advancement is also consistent with the maturing of the respondents through time.

Sequence and Length of Jobs

The sequence of jobs held by the respondents is presented in Table IV-3 with the location following the same geographic coding system described earlier and the level of employment basically following the census bureau's categorizations. The 348 technicians interviewed held a total of 1,404 jobs in their combined careers although only 1,081 appear in Table IV-3. This is because the current job classification is reserved for discussion and analysis later.

The definition of level of employment leaves some room for doubt with the exception of the operationally defined technical category. In soliciting their responses it was relatively easy to reach an agreement

TABLE IV-3

Distribution of Location and Level of Employment Among Sequence of Job

	Location					Level of Employment									N
Job Number	Greater Chicago	Downstate Metro	Downstate Rural	Out-of-State	Out of U. S.	Management	Professional	Technical	Skilled	Semi-skilled	Unskilled	Domestic	Farm Labor	Other	
1st* Job	206	41	35	49	17	6	3	84	50	99	98	0	6	2	348
2nd Job	155	33	23	45	14	6	9	55	61	79	49	4	3	4	270
3rd Job	110	28	16	24	7	10	6	46	48	50	25	0	0	0	185
4th Job	63	23	9	19	5	6	5	38	37	19	14	0	0	0	119
5th Job	37	16	9	13	3	9	4	23	26	8	7	0	1	0	78
6th Job	24	9	4	6	3	7	2	12	14	7	3	0	0	1	46
7th Job	14	6	1	2	0	5	0	7	5	2	3	0	1	0	23
8th Job	6	3	1	2	0	2	0	8	2	0	0	0	0	0	12
Totals	615	159	98	160	49	51	29	273	243	264	199	4	11	7	1081

Note: 1st job includes 25 technicians whose current job is their first.

with the respondent if the job was farm labor, domestic, unskilled, semi-skilled, skilled, or technical; but, the professional and management categories were more nebulous. Current jobs are not presented here because it would be redundant. Geographic data on current job was presented earlier and the level of employment for all respondents on current jobs is technical.

The length of time spent on the current job as compared to the first full time job held (see Table IV-4) reinforces earlier comments on the exploratory nature of the initial segment of occupational patterns. The first jobs held exceed the statistically expected frequency in the categories representing shorter lengths of time and then decline as the length of time on the job increases. The reverse is true for the current jobs even though not all of the respondents have reached occupational maturity.

Educational Attainment

Of the total sample, only 17 of the respondents had not completed high school. There were in addition to these, 23 who had received an equivalency diploma via the armed services or some similar general educational development test. As a result it seemed reasonable to treat educational attainment in terms of semester hours earned beyond high school with those who had not completed high school and those who had completed high school but had taken no additional formal education being recorded as having zero semester hours of educational attainment beyond high school.

TABLE IV-4

Comparison of Months on Job
First Job Held with Current Job

Months

	1-20	21-40	41-60	61-80	81-100	101-120	121&over	Total
1st Job	0 = 163 E = 122.40 X^2 = 13.47	0 =93 E =89.75 X^2 = .20	0 =42 E =49.80 X^2 = 1.22	0 =11 E =12.95 X^2 = .29	0 =15 E =21.25 X^2 = 1.84	0 = 6 E =11.40 X^2 = 3.56	0 =18 E =40.45 X^2 =12.46	348
Current Job	0 = 73 E = 113.60 X^2 = 14.51	0 =80 E =83.25 X^2 = .13	0 =54 E =46.20 X^2 = 1.32	0 =14 E =12.05 X^2 = .31	0 =26 E =19.75 X^2 = 1.98	0 =16 E =10.60 X^2 = 2.75	0 =60 E =37.55 X^2 =13.42	323*
Total	236	173	96	25	41	22	78	671

*Excludes 25 first jobs

X^2 = 66.46   df = 6 $P < .001$

It should be noted here that the method of assessing educational attainment permitted the inclusion of formalized study in public, private, military, and company schools and in addition included correspondence study, on the job or apprentice study that required some hours per week of formalized study, and self-study initiated by the respondent providing he could identify the subject matter area that it covered and could give a reasonable estimate of the number of hours spent on this. The respondent participated with the interviewer in making an equivalency statement. This was done after all of the educational experiences had been recorded and the number of hours spent in each activity had been noted. As a result, all of the educational activities beyond high school figure into the assessment of educational attainment.

Table IV-5 presents the distribution of the respondents among the various assessments of the educational experience. For each educational experience including high school, the location of this experience was noted consistent with the previously described geographic code. The categories for sources of education, type of program pursued, and student status are self explanatory.

There were no differences in the distribution among the three categories of general studies, college directed studies, and occupationally directed studies through time. Time was studied via the distribution of the type of program pursued by the age of the respondents. Although there was a minor fluctuation among those respondents who would be attending high

TABLE IV-5

Distribution of Education Experiences*

Level	Location						Source									Type					Student Status					N
	Did not Specify	Greater Chicago	Downstate Metro	Downstate Rural	Out-of-State	Out of U.S.	Public School	Private School	Military School	Company School	On-the-Job	Apprenticeship	Self Study	Coop	Correspondence	Did not Specify	General	College Directed	Occupational	Avocational	Full Time	Full Time,P.T.Work	Full Time,F.T.Work	Part Time,P.T.Work	Part Time,F.T.Work	
High School	3	185	34	45	57	24	307	34	6	0	0	0	0	0	1	5	104	134	105	0	348					348
First Post High School	0	164	33	21	79	28	148	92	37	11	6	10	1	2	18	1	11	69	239	5	170	20	4	5	126	325
Second Post High School	0	128	15	9	65	13	70	57	41	31	2	4	1	1	23	2	4	36	186	2	73	11	1	7	138	230
Third Post High School	0	65	7	8	44	10	47	16	32	15	9	2	4	0	9	0	1	16	111	6	46	4	0	2	82	134
Fourth Post High School	0	24	6	6	12	8	14	10	12	8	4	4	1	0	3	0	1	5	49	1	18	2	1	2	33	56
Totals for Post H.S. Experiences	0	381	61	44	200	59	279	175	122	65	21	20	7	3	53	3	17	126	585	14	307	37	6	16	379	745

*Note: There were a few technicians with more than four post H.S. experiences, but this table accounts for over 95% of all educational experiences beyond high school.

school in the early 40's, the rest of the age groups distribute themselves approximately equally among the three types of programs.

The type of program pursued when recorded against the location of the high school attended shows a significant relationship between the two. (See Table IV-6.) Illinois has a strong vocational-agricultural program throughout the downstate metropolitan, downstate rural areas. However, the majority of the programs in high school for industrial occupations are located in the greater Chicago area. This is inherent in the distribution shown in the above mentioned table.

It would be expected that the type of high school program pursued would be related to level of employment on the first job. These two variables are cross-tabulated in Table IV-7. The resulting Chi-square falls within the probability range of .02 to .05 which is sufficient to support the relationship. The cells within the distribution which contribute the greatest number to the total Chi-square are indicative of the relationship between the kind of high school program pursued and the kind of job the respondents were able to get for their first employment. Those who studied an occupationally oriented program exceed the statistically expected frequency in skilled jobs, the college directed program respondents exceed the expected frequency in technical jobs, and the respondents who had studied the general program exceed the expected frequency in the unskilled jobs. Without inferring a causal relationship it can be hypothesized that the traditional college directed high school program with its

TABLE IV-6

Type of High School Program Pursued by Geographic Location

Type

	General	College Directed	Occupation Directed	Total
Outside U.S.A.	O = 5 E = 7.38 X^2 = .77	O = 9 E = 9.33 X^2 = .01	O = 10 E = 7.30 X^2 = 1.00	24
Outside Illinois	O = 29 E = 17.51 X^2 = 7.54	O = 23 E = 22.14 X^2 = .33	O = 5 E = 17.35 X^2 = 8.79	57
Downstate Rural	O = 21 E = 13.83 X^2 = 3.72	O = 19 E = 17.48 X^2 = .13	O = 5 E = 13.71 X^2 = 5.53	45
Downstate Metropolitan	O = 17 E = 10.45 X^2 = 4.11	O = 11 E = 13.21 X^2 = .37	O = 6 E = 10.34 X^2 = 1.82	34
Greater Chicago	O = 34 E = 56.81 X^2 = 9.16	O = 72 E = 71.80 X^2 = .06	O = 79 E = 56.29 X^2 = 9.16	185
Total	106	134	105	345*

* 3 respondents never started high school

$X^2 = 52.50$ df = 8 $P < .001$

TABLE IV-7

Type of Program Pursued in High School and the Level of the First Job

Level

Type of Program	Management profession	Tech.	Skilled	Semi-skilled	Farm Labor	Other	Total
Occupation Directed	O = 2 E = 2.75 X^2 = .20	O = 21 E = 25.40 X^2 = .76	O = 24 E = 15.30 X^2 = 4.95	O = 31 E = 30.30 X^2 = .00	O = 25 E = 29.10 X^2 = .58	O = 2 E = 2.45 X^2 = 2.00	105
College Directed	O = 4 E = 3.50 X^2 = .07	O = 45 E = 32.45 X^2 = 4.85	O = 13 E = 19.55 X^2 = 2.19	O = 38 E = 38.70 X^2 = .01	O = 32 E = 37.10 X^2 = .70	O = 2 E = 2.70 X^2 = .18	134
General	O = 3 E = 2.75 X^2 = .02	O = 17 E = 25.15 X^2 = 2.64	O = 13 E = 15.15 X^2 = .30	O = 30 E = 29.80 X^2 = .00	O = 38 E = 28.80 X^2 = 2.94	O = 3 E = 2.15 X^2 = .31	104
Total	9	83	50	99	95	7	343*

* 5 respondents did not specify type of program (3 of these never started high school)

$X^2 = 20.70$ df = 10 $.02 < P < .05$

emphasis on science and mathematics was more in line with the needs of the technical positions than is the traditional occupationally oriented program with its emphasis on the crafts.

Since the first job does not necessarily relate to the ongoing career patterns of the respondents, the type of high school program pursued was cross-tabbed against the number of jobs held in each respondent's occupational career. (See Table IV-8.) The relationship, if any, was not significantly high to indicate that the type of high school program pursued was related to the number of jobs the individual would hold during his occupational career.

It has been well documented that our labor force is more and more mobile. This is inherent in the shift of job locations reported in Table IV-3, and this has caused considerable concern among vocational educators who are planning curriculum. The concept of local community surveys to justify vocational offerings at the high school level has been seriously challenged on the basis of occupational mobility. Table IV-9 presents the cross-tabulation of the location of the high school attended and the location of the first job. Without any statistical analysis on this tabulation, it is apparent from the distribution that a significant proportion of the respondents in this study found their first job in the same locality in which they had attended high school. It is also apparent that there is a movement out of the downstate rural area between high school graduation and the first job. This is consistent with other studies of

TABLE IV-8

Type of High School Program And Total Number of Jobs Held

Jobs Held

Type of Program	1	2	3	4	5	6	7 +	Total
Occupational	O = 5 E = 7.68 X^2 = .93	O = 17 E = 16.54 X^2 = .01	O = 28 E = 25.40 X^2 = .27	O = 25 E = 19.60 X^2 = 1.49	O = 12 E = 13.20 X^2 = .01	O = 5 E = 9.20 X^2 = 1.92	O = 13 E = 13.50 X^2 = .02	150
College Directed	O = 13 E = 9.76 X^2 = 1.07	O = 26 E = 21.08 X^2 = 1.15	O = 32 E = 32.43 X^2 = .00	O = 22 E = 25.00 X^2 = .36	O = 16 E = 16.80 X^2 = .04	O = 13 E = 11.70 X^2 = .14	O = 12 E = 17.20 X^2 = 1.57	135
General	O = 7 E = 7.56 X^2 = .03	O = 11 E = 16.38 X^2 = 1.77	O = 23 E = 25.17 X^2 = .19	O = 17 E = 19.40 X^2 = .30	O = 15 E = 13.00 X^2 = .31	O = 12 E = 9.10 X^2 = .92	O = 19 E = 13.30 X^2 = 2.44	104
Total	26	54	83	64	43	30	44	343*

*5 respondents did not specify type of high school program (3 of these 5 never started high school)

$X^2 = 14.94$ df = 12 $.20 < P < .30$

TABLE IV-9

Location of High School and Location of First Job

First Job

	Greater Chicago	Downstate Metro	Downstate Rural	Outside Illinois	Outside U.S.A.	Total
Outside U.S.A.	7			2	15	24
Outside Illinois	16	3	4	34		57
Downstate Rural	4	7	28	5	1	45
Downstate Metropolitan		29	2	3		34
Greater Chicago	178	2	1	4		185
Total	205	41	35	48	16	345*

* 3 respondents never started high school

labor force mobility which show an increasing concentration in the metropolitan areas in the United States.[5]

Current Positions

In the process of interviewing, the current job functions were classified by three coding systems. The coding systems were for the level of employment, the general area of employment, and the level within the general area of employment. These codes are in Appendix A as Form D. The purpose of having a number of levels of employment was to permit the classification of all of the jobs in the job history of the technician. It must be recognized that the definition of technician used for the selection of personnel forced all of our respondents into category three (technician) for the level of employment. The other two classifications (general area of employment and level within general area of employment) are more nearly associated with the functions performed by each of the technicians. The following table gives the breakdown of the distribution of the technicians among the general areas of employment and the levels within general area of employment. (See Table IV-10.)

The Chi-square indicates what whould be expected: that the two assessments of general area of employment and level within the general area of employment are dependent upon each other. The only category that was close to the statistically expected distribution across the levels within the general area was the 17 technicians in sales. The

TABLE IV-10

Distribution of Technicians Among the Basic Job Functions

		Eng. Tech. (Abstract)	Ind. Tech. (Prototype)	Specialist (Repetitive)	Supervisor	Totals
General Area of Employment	Maintenance	O = 0 E = 2.07 X^2 = 2.07	O = 2 E = 6.33 X^2 = 2.96	O = 9 E = 5.67 X^2 = 1.96	O = 7 E = 3.89 X^2 = 4.34	18
	Production	O = 18 E = 23.90 X^2 = 1.46	O = 54 E = 73.42 X^2 = 51.37	O = 86 E = 65.85 X^2 = 6.16	O = 50 E = 44.83 X^2 = .60	208
	Sales	O = 1 E = 1.95 X^2 = .46	O = 7 E = 6.15 X^2 = .12	O = 5 E = 5.30 X^2 = .01	O = 4 E = 3.60 X^2 = .05	17
	R & D	O = 21 E = 12.1 X^2 = 6.55	O = 60 E = 37.10 X^2 = 14.13	O = 10 E = 33.16 X^2 = 16.18	O = 14 E = 22.64 X^2 = 3.30	105
	Totals	40	123	110	75	348

$X^2 = 109.72$ df = 9 $P < .001$

other variations from the statistically expected distribution are consistent with our knowledge of industrial manufacturing processes. We would expect that most technicians involved with maintenance would fall either in the specialist (repetitive), or supervision category. Those within the specialist category would be involved in maintenance of highly sophisticated systems, and those in supervision could be supervising workmen of a lower level in the maintenance of either sophisticated or relatively complex machines and systems. It is not surprising to find technicians in the production category exceeding the expected statistical frequency for those technicians in the repetitive and supervision categories. These men would generally fall on the lower end of the technician spectrum. The distribution of technicaans involved in research and development again follows a logical distribution. A significant proportion of the technicians were involved in abstract engineering or in the development of prototypes which is classified as industrial technology.

Age was found to be related to level of employment in the current position. (See Table IV-11.) The older respondents are more likely to be in the supervision, prototype development, and abstract research than are the younger men. The younger men exceed the statistically expected frequency in the technician specialist classification which involves repetitive work. The relationship between age and function is consistent with the concept that industrial experience is necessary to

TABLE IV-11

Distribution of Age Groups Among Current Levels of Employment within the General Areas

Level Within	17-21	22-26	27-31	32-36	37-41	42-46	47-51	52&over	Total
Supervisor	0 = 1 E_2= 3.67 X = 1.92	0 = 7 E_2=16.35 X = 5.35	0 =10 E_2=14.25 X = 1.27	0 =13 E_2=10.80 X = .45	0 =12 E_2= 9.29 X = .78	0 =14 E_2= 9.45 X = 2.19	0 =13 E_2= 7.33 X = 4.34	0 = 5 E_2= 3.88 X = .31	75
Specialist	0 =10 E_2= 5.38 X = 3.93	0 =33 E_2=24.03 X = 3.39	0 =24 E_2=20.85 X = .46	0 =13 E_2=15.83 X = .51	0 = 9 E_2=13.60 X = 1.58	0 =10 E_2=13.86 X = 1.08	0 = 5 E_2=10.75 X = 3.10	0 = 6 E_2= 5.70 X = .01	110
Ind. Tech. Prototype	0 = 3 E_2= 6.03 X = 1.51	0 =30 E_2=26.90 X = .38	0 =27 E_2=23.30 X = .56	0 =19 E_2=17.61 X = .09	0 =17 E_2=15.20 X = .20	0 =15 E_2=15.53 X = .02	0 = 8 E_2=12.03 X = 1.36	0 = 4 E_2= 6.40 X = .90	123
Eng. Tech. Abstract	0 = 3 E = 1.95 X^2= .55	0 = 6 E = 8.72 X^2= .85	0 = 5 E = 7.60 X^2= .89	0 = 5 E = 5.76 X^2= .10	0 = 5 E = 4.91 X^2= .00	0 = 5 E = 5.15 X^2= .00	0 = 8 E = 3.92 X^2= 4.22	0 = 3 E_2= 2.02 X = .41	40
Totals	17	76	66	50	43	44	34	18	348

X^2 = 42.77 df = 21 $.001 < P < .01$

make a contribution to the production in a given industry. Considering the well established negative correlation between age and educational attainment, it is not surprising that educational attainment was found to have no relationship to the current level of employment within each of the general areas.

Salary

It was anticipated that there might be difficulty soliciting responses on salary earned at the various jobs and particularly at the current job. For this reason a coding scale was developed and placed in a plastic casing which the respondent used to indicate a code number to the interviewer to identify salary earned. This scale is shown as Form F in Appendix A.

The range of salaries for the current job covered the entire range shown on the code sheet. The distribution of salaries among the levels within the job functions is reported in Table IV-12.

As per the following table, age, salary, and the length of time on the current job are all highly correlated with one another. This is an understandable phenomena since both age and length of time on the current job reflect the possibility of experience and industry is not hesitant to reward experience in terms of salary on the assumption that experience and productivity are highly correlated.

TABLE IV-12

Salary and Level Within Job Function

Annual Salary	Eng. Tech. (abstract)	Ind. Tech. (prototype)	Tech. Spec. (repetitive)	Supervisor	Total
$11,501 & over	O = 2 E = 2.06 X^2 = .00	6 6.42 .02	2 5.69 2.39	8 3.83 4.54	18
$ 9,501 to 11,500	O = 5 E = 3.91 X^2 .30	9 12.00 .75	4 10.75 4.24	16 7.31 10.33	34
$ 7,501 to 9,500	O = 16 E = 13.34 X^2 = .53	41 41.00 .00	29 36.66 1.60	30 25.00 1.00	116
$ 5,501 to 7,500	O = 15 E = 15.64 X^2 = .02	56 48.00 1.33	46 43.90 .21	19 29.36 3.66	136
Under $5,500	O = 2 E = 5.05 X^2 = 1.85	11 15.58 1.35	29 13.90 16.40	2 9.47 5.89	44
Total	40	123	110	75	348

$X^2 = 56.41$ df = 12 $P < .001$

	Age	Salary	Length
Age	X		
Salary	.595	X	
Length	.572	.371	X

.138 and above are significant at 1%

N = 348

The Chi-square computed in Table IV-12 have a .001 probability of occurring by chance. Consequently, it must be concluded that the salary level and job function are related as were salary and age, length of time on the job and age, and length of time on the job and salary. It would seem natural that all of these things are intracorrelated. It seems logical, too, that inspecting the internal distribution of the above reported Chi-square matrix the supervisors exceed the expected frequencies in the upper salary level brackets and fall below the expected frequencies on the lower end of the salary continuum while the reverse is true of the technician specialists. This is consistent with earlier remarks that the technician specialists, the repetitive type of job, is the basic entry job for the younger men coming into the technologies. It is not surprising that length of time on a job, and age, which is equivalent to experience, are related to the amount of salary industry is willing to pay its technicians; nor is it surprising that the age is related to the supervisory duties since experience is an important factor in the supervision function in industry.

When the general area of employment and the level of employment within that general area are combined to form a two digit code the result is a more specific categorization of job function for the current employment situation. The resultant two digit code identifies engineering technicians in research and development, industrial technicians in research and development, and the rest of the cells in Table IV-10. The distribution remains highly related to salary, age and educational attainment with the contingency coefficients being:

combined code on current employment and salary = .41

combined code on current employment and educational attainment = .36

combined code on current employment and age = .32

Occupational Mobility

The function of occupational mobility in this report is to attempt to measure job success for the current jobs held by the respondents. The rating arrived at through the process defined below will then be compared with other criteria of success such as salary on current position.

Each job change recorded during the interviews was categorized in terms of its status, responsibility, and function in relation to the previous job held by that respondent.

Job Changes

Inter-job mobility was categorized according to the following format. The number in parentheses preceeding each category is the number of job changes that received that coding.

(25) 0 equals no job changes.

(4) 1 equals moves downward within the establishment.

(103) 2 equals moves downward to another establishment.

(21) 3 equals moves to equivalent job within the same establishment.

(112) 4 equals moves to equivalent jobs at another establishment.

(12) 5 equals moves forced by service committments or similar non-voluntary impingements which by their nature should not have an effect upon overall occupational career assessments.

(224) 6 equals moves upward in job assignment within the same establishment.

(580) 7 equals moves upward in job assignment involving a move to another establishment.

To recap, there were 1,404 jobs held by the 348 respondents. Job changes are necessarily 348 less than the number of total jobs held; hence, there were 1,056 job changes. However, to minimize the effects of time (both the opportunity for job changes and the changing economic structure which may increase the necessity of job change) only those changes which took place during the past ten years will be used in the assessments of overall occupational mobility.

Of the job changes during the past ten years, 139 were within the same establishment and 474 were moves to other establishments. Differentiating between moves within and moves without establishments was necessary to insure knowledge about the length of time with the current establishment and it is not necessary for defining occupational mobility as will be seen from the following definitions. The distribution of job changes among the categories of downward, horizontal and upward for the past ten years is shown below.

downward moves	80
horizontal moves	76
upward moves	455

From Job Changes to Occupational Mobility

Eighteen of the respondents had worked less than five years and had made no moves; therefore, no assessment could be made of their occupational careers. The remaining 330 respondents were assigned to one of the following four career categories according to the schema outlined below. This schema has been used before by the author in assessing occupational careers.[6]

Career Patterns

1. Downwardly mobile. All the job changes during the past ten years were downward or the downward moves plus the horizontal moves exceeded the upward moves.

2. Horizontally mobile. All the job changes during the past ten years were horizontal or the horizontal moves equal or exceed the upward moves or the downward and horizontal moves combined equal the upward moves.

3. Stable. The respondent had been on the current job for ten years or more or he had been on the current job for five years or more and it was the only job ever held.

4. Upwardly mobile. All the job changes were upward during the past ten years or the upward moves exceeded allother moves combined.

Through the application of the schema there were 21 downwardly mobile respondents, 47 horizontally mobile respondents, 75 stable respondents, and 187 upwardly mobile respondents.

The occupational career patterns were then compared with age and job change assessment for the last move to test the independence of the occupational career categories. (See Tables IV-13 and IV-14.) Salary and educational attainment were also compared with occupational career patterns. (See Table IV-15.)

Occupational mobility patterns were assessed via the Chi-square to investigate the relationship between the patterns of occupational mobility derived and with salary and with educational attainment. The results are shown in Tables IV-15 and IV-16.

Occupational mobility patterns are highly related to salary which is another common criterion of job success. The mobility pattern, however, shows no relationship to educational attainment. This is an understandable phenomena since age, length of time, and job experience are related to current job assignment and salary. Although educational attainment is negatively correlated with age, it appears to be an

TABLE IV-13

Occupational Mobility and Job Movement to Current Job

	Down	Horizontal	Stable	Upward	Total
Down (1)	O = 8 E = .80 X^2 = 6.48	O = 5 E = 1.45 X^2 = 8.69	O = 0 E = .46 X^2 = .46	O = 8 E = 18.31 X^2 = 5.81	21
Horizontal (2)	O = 3 E = 1.71 X^2 = .97	O = 13 E = 3.26 X^2 = 28.79	O = 0 E = 1.01 X^2 = 1.01	O = 31 E = 41.01 X^2 = 2.44	47
Stable (3)	O = 0 E = 2.73 X^2 = 2.73	O = 2 E = 5.23 X^2 = 1.99	O = 7 E = 1.58 X^2 = 18.59	O = 66 E = 65.45 X^2 = .00	75
Upward (4)	O = 1 E = 6.76 X^2 = 4.91	O = 3 E = 13.06 X^2 = 7.75	O = 0 E = 3.95 X^2 = 3.95	O = 183 E = 163.23 X^2 = 2.39	187
Total	12	23	7	288	330

$X^2 = 71.05$ df = 9 $P < .001$

TABLE IV-14

Occupational Mobility and Age Groups

	29 or less	30-39	40-49	50 & over	Total
Down (1)	O = 11 E = 7.68 X^2 = 1.43	O = 3 E = 5.98 X^2 = 1.48	O = 7 E = 5.45 X^2 = .44	O = 0 E = 1.90 X^2 = 1.90	21
Horizontal (2)	O = 24 E = 17.22 X^2 = 2.67	O = 13 E = 13.38 X^2 = .01	O = 9 E = 12.13 X^2 = .81	O = 1 E = 4.27 X^2 = 2.50	47
Stable (3)	O = 6 E = 27.50 X^2 = 16.81	O = 15 E = 21.36 X^2 = 1.89	O = 33 E = 9.32 X^2 = 60.17	O = 21 E = 6.82 X^2 = 2.08	75
Upward (4)	O = 80 E = 68.60 X^2 = 1.89	O = 63 E = 53.28 X^2 = 1.77	O = 36 E = 48.10 X^2 = 3.04	O = 8 E = 17.01 X^2 = 4.77	187
Total	121	94	85	30	330

$X^2 = 103.66$ df = 9 $P < .001$

TABLE IV-15

Occupational Mobility & Educational Attainment

Educational Attainment	Mobility 1	2	3	4	Total
121+	O = 2 E = .69 X^2 = .02	1 1.57 .20	3 2.51 .09	5 6.23 .24	11
101 - 120	O = 0 E = 1.78 X^2 = 1.78	8 3.99 4.03	5 6.37 .29	15 15.87 .05	28
81 - 100	O = 1 E = 2.16 X^2 = .63	8 4.85 2.05	9 7.73 .21	16 19.26 .55	34
61 - 80	O = 3 E = 2.35 X^2 = .18	4 5.27 .31	7 8.41 .24	23 20.96 .20	37
41 - 60	O = 6 E = 3.44 X^2 = 2.05	6 7.69 .37	12 12.27 .01	30 30.60 .01	54
21 - 40	O = 4 E = 3.44 X^2 = .13	6 7.69 .37	12 12.27 .01	32 30.60 .06	54
1 - 20	O = 3 E = 4.21 X^2 = .35	11 9.39 .27	13 14.99 .26	39 37.40 .07	66
0	O = 2 E = 2.93 X^2 = .29	3 6.55 1.92	14 10.45 1.21	27 26.06 .03	46
Total	21	47	75	187	330
	.064	.142	.227	.567	

$X^2 = 18.48$ df = 21 $.50 < P < .70$

TABLE IV-16

Occupational Mobility and Salary

Salary	Mobility				
	1	2	3	4	Total
17+	O = 1 E = 1.33 X^2 = .08	1 2.59 .98	9 4.11 5.82	7 10.19 1.00	18
13 - 16	O = 0 E = 2.35 X^2 = 2.35	4 4.86 .15	11 7.73 1.38	19 19.26 .00	34
9 - 12	O = 8 E = 8.14 X^2 = .00	21 18.23 .42	39 29.09 3.38	60 70.53 1.57	128
5 - 8	O = 7 E = 7.25 X^2 = .00	15 16.24 .09	13 25.91 6.43	79 64.60 3.24	114
1 - 4	O = 5 E = 2.29 X^2 = 3.21	6 5.13 .15	3 8.18 3.29	22 20.40 .13	36
Total	21	47	75	187	330

$X^2 = 33.67$ df = 12 $P < .001$

independent variable.

Classification by Discipline

It is common to label technician positions according to the discipline upon which the position is predicated. The respondents in this study were classified in the above manner with the following result.

	N
Mechanical Engineering Technicians	163
Electrical - Electronic Technicians	49
Chemical Technicians	53
Data Processing Technicians	4
Electro - Mechanical Technicians	43
Electro - Chemical Technicians	9
Chemical - Mechanical Technicians	27
	348

Each classification was represented in a number of manufacturing areas and there was no relationship between the above classifications and our measures of salary, educational attainment, age, job mobility, or occupational career patterns.

Summary

The data presented in this chapter serve two functions. First, the data provide a descriptive picture of the technician, his functions in manufacture, his educational background and his occupational background.

Second, the data set the stage for the multivariate analysis of the card sort which will be presented in the next chapter.

As is the case with much social data, many of the variables analyzed in this chapter are intercorrelated. The relationships were investigated by either product-moment correlations, Chi-square or contingency coefficients whichever were appropriate.

Occupational mobility as derived in this report turns out to be highly related to age, salary, and the movement from the previous job to the current job. As the consequence, our occupational mobility categories can be accepted as measures of job success on the current job and be used as an important variable in the analysis of the card sort.

Educational attainment, which is negatively correlated with age and shows no relationship to occupational mobility patterns, will be another important variable in the analysis of the card sort.

FOOTNOTES

1. *United States Census of Population: 1960*, U. S. Department of Commerce, (Washington: 1961), pp. 15-61 & 15-62.

2. D. C. Miller and W. H. Form, *Industrial Sociology*, (New York: Harper & Brothers, 1951), pp. 604, 651-652.

3. S. M. Lipset and R. Bendix, *Social Mobility in Industrial Society*, (Berkeley and Los Angeles: University of California Press, 1959).

4. Theodore Caplow, *The Sociology of Work*, (Minneapolis: The University of Minnesota Press, 1954), p. 134.

5. *Governor's Conference on Youth Employment*, State of Illinois, June 5-6, 1962.

6. William John Schill, *Career Patterns of Technical and Vocational Educators*, (Danville: Interstate Printers & Publishers, Inc., 1963).

CHAPTER V

CARD SORT ANALYSIS

Prior to describing the analysis of the responses to the card sort, it seems imperative that the methodology of the sort itself be reviewed and summarized.

The respondents were instructed to read through the cards and distribute them into three initial categories. The distribution was based upon the relationship of the knowledge on each card to successful job performance. (See Form G in Appendix A.) The initial categories were (1) those cards closely related to their job performance, (2) those cards somewhat related to their job performance, and (3) those cards unrelated to their job performance. These responses were then tabulated (see Form B in Appendix A). The number of cards placed in the related category ranged from 0 to 49 with a mean of 15.22; the number of cards placed in the somewhat related category range from 1 to 58 with a mean of 18.07. The total number of cards placed in the two related categories ranged from 5 to 71 with a mean number of cards being 33.29 or about one third of the cards.

After the respondents had finished the initial sort they were then asked to reread the cards and distribute them into the left hand tail of the normal distribution (see Form C in Appendix A) as per instructions (see Form G in Appendix A).

Card Content

The panel of experts from the various academic disciplines mentioned earlier, in addition to responding to the coverage of their discipline offered by the various cards included in the card sort, were also asked to rate the cards from their area in terms of the wording of the description of that particular aspect of the knowledge. They rated this on a five-point scale from abstract to application. These ratings were subsequently cross-tabulated against the major categories of academic disciplines and are reported in Table V-1.

There were 42 cards that were rated as abstract definitions of knowledge, 26 rated as neutral (middle of the scale from abstract to application), and 31 cards rated as application. Forty-six of the cards described the knowledge from the physical sciences, 19 from the mathematical sciences, 17 from the biological sciences, and 10 from the social sciences. The remaining 10 were classified as general knowledge common to a number of disciplines.

The Chi-square (see Table V-1) demonstrated that the abstract to application continuum is related to the academic discipline represented on the cards. Mathematical sciences was more likely to be expressed in abstract terms and the area of general knowledge was more likely to be expressed in terms of application while the biological, physical, and social sciences followed closely the statistically expected frequencies in their distribution.

TABLE V-1

Abstract - Application and Academic Discipline Represented on the Cards in the Card Sort

	Abstract	Neutral	Application	Total
Physical Sciences	O = 21 E = 18.9 $X^2 = .22$	O = 12 E = 11.7 $X^2 = .00$	O = 13 E = 15.4 $X^2 = .4$	46
Mathematical Sciences	O = 15 E = 7.8 $X^2 = 6.6$	O = 3 E = 4.9 $X^2 = .7$	O = 1 E = 6.3 $X^2 = 4.5$	19
Biological Sciences	O = 4 E = 7.0 $X^2 = 1.3$	O = 5 E = 4.3 $X^2 = .1$	O = 8 E = 5.7 $X^2 = .9$	17
Social and Behavioral Sciences	O = 2 E = 4.1 $X^2 = 1.1$	O = 4 E = 2.6 $X^2 = .7$	O = 4 E = 3.3 $X^2 = .1$	10
General Sciences	O = 0 E = 4.1 $X^2 = 4.1$	O = 2 E = 2.6 $X^2 = .1$	O = 8 E = 3.3 $X^2 = 6.2$	10
Total	42	26	34*	102*

* Three cards appear in both biological & physical science

$X^2 = 27.02$ df = 8 $P < .01$

Using a technique for assigning values to the placement of the cards in the respondent's sorts (the assignment of values is explained in detail below), these values were summed across items. The mean value for the combination of items making up the various categories was computed with the result that the application items carry consistently higher rank than the neutral or the abstract items, and that the discipline areas for which the cards were purported to describe knowledge were subsequently ranked in this fashion. The general knowledge was first; the social and behavioral sciences were second; the mathematical sciences were third; the physical sciences were fourth; and the biological sciences were last. Since the two rating systems were highly related, there is no need to pursue any further the abstract-application concept and we can rely upon the discipline areas for further analysis of the card sort.

The ratings assigned to the various card sort items are reported as Form H in Appendix A along with the entire content of each card.

Assignment of Values to the Sorts

As was mentioned earlier in this report the normal distribution technique was not applicable in this card sort and consequently the data had to be treated by nonparametric statistics. Values ranging from 7 through 0 were assigned to the responses with value seven being assigned to the first category in the left hand tail of the forced sort in which there were three cards, value six being assigned to the second category in which there were five cards, value five being assigned to the third category in which there were eight cards, and so on down to value one being assigned to the category just past the mean of the distribution in which there were 14 cards. Not all respondents had this many cards functionally related to their job so at the point where the related cards were exhausted, positive values ceased to be assigned and whatever cards were left over were given a value of zero. The range of the number of positive responses to a card was from 8 to 270 with a mean of 115.67. When the value assigned each card was summed across all of the respondents, the resulting range of total values was from 16 to 1,443.

The method of assigning values and then summing of the values across respondents caused a number of raw measures to be highly correlated with the summation value.

	Number of Items in Related	Number of Items in Somewhat Related	Number of 7 Ratings	Number of Positive Ratings
Σ value	.789	.813	.803	.988

All of the correlations given above are significant beyond the one percent level. The result of this preliminary check on the relationships of the methods of rating the items was sufficient to justify using the summation of the values assigned to an item as its relative importance as seen through the eyes of the working technicians. The sums, rank orders, distribution by level of response for each of the items is reported in Table I in Appendix B.

Occupational Variables and the Card Sort

To measure the extent of agreement on the items in the card sort among the various groups conceived to have a possible confounding effect upon the card sort, the coefficient of concordance was used. The coefficient of concordance was completed among the four groups of occupational mobility with the results as follows.

$W = .919 \quad k = 4 \quad N = 99 \quad P < .001$

The coefficient of concordance among the groups on educational attainment had the following results.

$W = .890 \quad k = 8 \quad N = 99 \quad P < .001$

The coefficient of concordance among the two digit code categories for general area of employment and level within the general area of employment had the following results.

$W = .845 \quad k = 10 \quad N = 99 \quad P < .001$

The coefficient of concordance among the disciplines underlying the technology was:

$W = .571 \quad k = 7 \quad N = 99 \quad P < .001$

The coefficients of concordance listed above demonstrate the strong general agreement on the placement of the items across the technologies. When the specific technologies (for example, mechanical engineering technology) were partialed individually on age and type of job function, the agreements remained sufficiently strong to be significant.

Individual's Responses to the Card Sort

To investigate the effects of personal and job data upon the individual's responses to the card sort, the sums of the values assigned to the cards were summed across individuals and then the individual's summation value was used to rank all 348 technicians. Once this was done the technicians were grouped in the same manner as reported previously on mobility, length of time on current job, salary, educational attainment, technology within which they were functioning on their current job, age, and the two digit code for current position. In each case the groups were compared by using the Kruskal-Wallis one way analysis of variance.

The result of this analysis was that length of time on current job, mobility, educational attainment, and the technology within which the respondent was functioning did not yield a sufficiently high (H) to be significant at the one percent level, which has been used as level of significance throughout this report.

There were three groupings that did differ significantly on the computed one way analysis of variance. These are shown below along with the computed statistic.

One way analysis of variance on salary groupings:

$H = 36.17$ $df = 8$ $P < .001$

One way analysis of variance by age:

$H = 12.78$ $df = 3$ $.001 < P < .01$

One way analysis of variance by two digit code on current job function:

$H = 38.63$ $df = 9$ $P < .001$

As has been shown in previous chapters, salary, age, and current job function are highly correlated. It has been suggested that experience and the age of the respondent contribute to his movement within the realm of technological employment to positions of more authority and this has again contributed, in this case, to the number of cards the respondents see as being related to their job. The order of the respondents in terms of descending number of cards included in the related category is as follows.

(1) research and development supervisors

(2) research and development engineering technicians

(3) maintenance technicians

(4) research and development industrial technicians

(5) production supervisors

(6) production engineering technicians

(7) sales technicians

(8) production industrial technicians

(9) research and development technical specialists

(10) production technical specialists

It has been stated previously that the technical specialists are generally the young men entering the technologies; that is, the entry occupation. The supervision categories are positions held by older men with experience in the technologies who have been rewarded by management for their past productivity. It is therefore reasonable to assume that the differences in the number of cards rated as related to job function is consistent with the broader scope of the jobs and is not a function of the card sort instrument itself.

Identifying the Knowledges Common to the Technologies

The analysis reported thus far is sufficient to conclude that there are common knowledges required of the various technologies and level of job function within the technologies. Attempts to differentiate between successful and less successful technicians were by and large unrewarding. As a consequence, the responses from all of the technicians will be used to identify the knowledges common across the technologies that are functionally related to job performance in these technologies. It is recognized that in this process, the respondents with supervisory positions or positions requiring extended experience will tend to inflate the amount of knowledge functionally related to job performance. This seems acceptable considering the objectives of vocational and technical education. Vocational and technical education aspire to prepare students for entry occupations in the technologies and at the same time supply them with the necessary competencies which will permit them to progress within their chosen field. Thus, the inflationary effects of including the upper strata of technicians will not have an unrealistic effect upon the programs to be recommended in the subsequent chapter.

It had been originally proposed that factor analysis would be used to identify the knowledges common to the entire body of respondents and the specific knowledges required by the various technologies. This was not possible because of the strong agreement across all of the technologies with the resulting effect of deflating measures of correlation and covariance upon which factor analysis methods are predicated. For this reason the knowledges common to all of the technicians were abstracted from rank order analysis and the knowledges demonstrated to be of no functional value to all of the technologies were also deleted by inspection of the rank order responses.

The highly significant coefficient of concordance does not imply that the respondents agreed on the placement of every item. Inspection of the rank orders indicates that there was strong agreement on the top end of the rank orders and on the lower end. The procedure used to identify those items that contributed the most greatly to the significant coefficient of concordance was to delete from further analysis those items at the top on which there were strong agreement and place them in the category of knowledges required across all of the technologies and to delete from the bottom the items on which there was agreement of no need and placed them in the category of being unrelated to job performance of any of the technologies. The procedure was to delete items from both ends on the basis of strong agreement until the coefficient of concordance dropped below the one percent level of confidence, which means that the items deleted had contributed most greatly to the over all agreement among the respondents. In this fashion 13 items were deleted from the top and placed in the category of knowledge generally required of all technicians and 42 items were deleted from the bottom as being knowledges of little or no value to any of the technical categories. More will be said about these items in the subsequent chapter on recommendations for curriculum content.

At the point at which the coefficient of concordance across the technologies ceased to be significant, the stage had been set for factor analysis of the remaining items. Consequently, there were 44 items to factor analyze. This was done on a two-mode factor analysis using items and individuals via the principal axis rotation method and the results are described in the following chapter on curriculum recommendations.

The content included on each of the cards is shown as Form H in Appendix A and the number on the card is the one that was used in the recording processes during the data collection and analysis. It suffices at this point to list those items that are included in the general requirements for all the technologies, but since those items unrelated to performance will not enter into the discussion of recommended curricula some brief comments on them follow the list of items related and unrelated. (See Table V-2.)

TABLE V-2

Card Numbers for Knowledges Functionally Related to All Technologies	Card Numbers for Knowledges Unrelated to Performance for Any of the Technologies		
1	2	24	64
3	5	25	68
17	6	29	69
98	7	31	74
51	9	62	76
52	10	39	78
53	11	40	82
61	13	43	96
63	14	45	87
65	15	48	88
66	16	49	91
67	19	50	94
77	20	54	95
	21	55	
	22		

The items set aside in the coefficient of concordance analysis were subjected to Chi-square analysis and compared with the abstract-application continuum and the academic discipline classifications, with the results as shown on Tables V-3 and V-4. There was no statistical relationship between abstract-application continuum and the items related to job performance in all the technologies, the items saved for factor analysis, and the unrelated items. There was, however a significant relationship between these categories and the academic disciplines. The Chi-square involving the academic disciplines was computed two ways--in the manner presented in table four and it was computed by combining the related items with those items saved for factor analysis in order to avoid the extremely small expected frequencies in a number of cells.

When this was done the resulting Chi-square equaled 13.48, the degrees of freedom became 4 and the probability remained at less than .001. For this reason only the expanded distribution was reported since it gives a little better picture of the distribution of the related and unrelated items across the disciplines.

The greater part of the Chi-square came from mathematics having greater than the statistically expected frequency in the related cell, the area of general knowledge being greater than the expected frequency in the related cell, and the biological sciences being less than the expected frequency in the related cell and greater than the expected frequency in the unrelated cell. From this we can conclude that the biological sciences are of little importance to the performance of the technicians in the seven categories of technology represented in this study.

The items in the unrelated categories for the physical sciences embraced primarily those items relating to food chemistry, mineralogy, nucleonics, and various forms of propulsion.

The items in the unrelated category for the mathematical sciences, with one exception, deal with the upper levels of the mathematic continuum and with computer programming and operations. The one exception is the use of principles of plane surveying.

The items rejected by the respondents from the domain of the social sciences were all related to the organization, development, laws, and labor involvements of the business structure.

TABLE V-3

Distribution of Items Among Related - Unrelated and Abstract - Application Classifications

	Related	Saved for Factor Analysis	Unrelated	Total
Abstract	O = 3 E = 5.5 X^2 = 1.14	20 17.4 .39	19 19.1 .00	42
Neutral	O = 4 E = 3.4 X^2 = .10	8 10.8 .13	14 11.8 .41	26
Application	O = 6 E = 4.1 X^2 = .88	13 12.8 .00	12 14.1 .31	31
Total	13	41	45	99

$X^2 = 3.36$ df = 4 $.70 > P > .50$

TABLE V-4

Distribution of Items Among Related - Unrelated and Academic Discipline Categories

	Related	Saved for Factor Analysis	Unrelated	Total
Physical Science	O = 3 E = 5.8 X^2 = 1.35	26 19.9 1.87	17 20.3 .54	46
Mathematical Science	O = 4 E = 2.4 X^2 = 1.06	7 8.2 .17	8 8.4 .02	19
Biological Science	O = 0 E = 2.2 X^2 = 2.2	3 7.3 2.53	14 7.5 5.63	17
Social Science	O = 0 E = 1.3 X^2 = 1.3	6 4.3 .67	4 4.4 .04	10
General	O = 6 E = 1.3 X^2 = 4.7	2 4.3 1.23	2 4.4 1.31	10
Total	13	44*	45	102

* Includes 3 items recorded in both biological and physical science

$X^2 = 24.62$ df = 8 $P < .001$

Perhaps the most surprising aspect of the foregoing discussion is the rejection of computer operation and programming by the technicians in this study. There were a number of establishments at which technicians were interviewed that used computers either in their office procedures or in production inventory, and in one case in on-line control of the production process. In the case where the computer was used on line to control the production process, engineers from the company that built the computer were in charge of the facilities and would continue to be in charge for two years during which time it was expected that some members of the permanent working force would acquire the necessary skills to maintain and operate the computerized production. In the other cases, the operation and programming of the computers were in the hands of engineers or management personnel with degrees and henceforth were not included in our technician categories. The instances where technicians were involved with computers, were those where the system had been so structured that its operation was very routine and the technician's involvement were with the maintenance of the electronic circuitry and not with the programming or console operation of the computer. It can be expected that with the increasing use of computers in American industry there will be more and more need for knowledge about computer operation and programming. At the same time, it is conceivable that as the use expands the operation and maintenance will become routinized and be of the cookbook variety so as to not require knowledge pertaining to the physics and mathematics inherent in the computer operation.

Factor Analysis of the Residual Items

The factor analysis used was a two mode factor analysis using the principal axis methods. Because of the possibility of both high and low rankings on each of the residual items by all of the respondents, the factors were necessarily bipolar. This permitted the classification of the items into related and unrelated categories for the various technicians depending upon the positive or negative value of the factor loading by items and by individuals.

Factor scores of .2 and above were used to identify items for the underlying factors. Although it is generally not very well accepted to use factor analysis to investigate relationships among variables that is the manner in which factor analysis is used herein. It may be considered a matter of expediency because no other statistic would assist in the logical interpretation of the remaining 41 items to which the respondents had assigned values. The factors identified as underlying measure of the item responses are as follows, with only factor number one being bipolar and the rest of the factors having single poles with negative factor scores for all of the items therein.

Factor I

Positive Pole (Metal Processing)

Item	Factor Score
35	.240
72	.271
73	.269
37	.251

Negative Pole (Ind. Chemistry)

Item	Factor Score
32	- .274
79	- .289
81	- .219
86	- .264
83	- .249
84	- .233
97	- .209

Factor II

Negative Pole (Electronics

Item	Factor Score
8	- .319
12	- .309
18	- .334
57	- .319
71	- .326
75	- .311

Factor III

Negative Pole (Mechanics)

Item	Factor Score
33	- .301
34	- .250
36	- .273
38	- .242
47	- .227
60	- .231
89	- .258
92	- .224

Factor IV

Negative Pole (Supervision & Ind. Mgmt.)

Item	Factor Score
23	- .342
26	- .382
27	- .276
28	- .348
30	- .327
42	- .269
44	- .213

Factor V

Negative Pole (Metallography)

Item	Factor Score
35	- .269
70	- .407
90	- .338
99	- .423

The intercorrelation of the items for each of the five factors are presented in the following tables. (See Table V-5)

When the factor loadings for individuals were tabulated across the above mentioned factors, the result was that mechanical engineering technicians were heavily loaded on metal processing, the electricity-electronics technicians were heavily loaded on electronics, the chemical technicians were heavily loaded on industrial chemistry, the electro-mechanical technicians were heavily loaded on electronics and secondarily on metal processing, the electro-chemical technicians were loaded on industrial chemistry and the chemical-mechanical technicians were heavily loaded on mechanics and secondarily on supervision. In addition, there were some isolated items which did not appear in any of the factors but still have meaning for the curriculum recommendations of the various technologies. The recommendations in the forthcoming chapter are predicated upon those items included in the factors for that technology and in addition to selected items with high relative summation values for that technology.

TABLE V-5

Item Correlations within Factors

Factor I Item Correlations

Metal Processing Factor

Industrial Chemistry Factor

35											
37	.701										
72	.565	.564									
73	.608	.580	.570								
79	-.281	-.385	-.459	-.391							
32	-.208	-.236	-.274	-.252	.398						
81	-.321	-.332	-.348	-.340	.397	.501					
83	-.249	-.269	-.371	-.397	.489	.578	.597				
84	-.233	-.245	-.282	-.236	.440	.447	.488	.486			
86	-.210	-.157	-.228	-.230	.247	.393	.428	.502	.380		
97	-.214	-.258	-.362	-.280	.320	.436	.512	.492	.405	.456	
	35	37	72	73	79	32	81	83	84	86	97

Factor II Item Correlations

(Electronics)

8						
12	.641					
18	.751	.664				
57	.733	.693	.751			
71	.725	.670	.761	.809		
75	.466	.505	.541	.506	.506	
	8	12	18	57	71	75

TABLE V-5
(continued)

Factor III Item Correlations

(Mechanics)

33								
34	.459							
36	.488	.523						
38	.548	.405	.399					
47	.312	.329	.317	.466				
60	.350	.332	.324	.277	.412			
89	.260	.317	.350	.110	.112	.115		
92	.179	.196	.261	.038	.042	.098	.582	
	33	34	36	38	47	60	89	92

Factor IV Item Correlations

(Supervision & Industrial Management)

23							
26	.539						
27	.361	.408					
28	.477	.494	.612				
30	.416	.495	.314	.440			
42	.363	.437	.489	.501	.333		
44	.240	.272	.302	.294	.218	.274	
	23	26	27	28	30	42	44

Factor V Item Correlations

(Metallography)

35				
70	.391			
90	.061	.378		
99	.046	.255	.311	
	35	70	90	99

FOOTNOTES

Lee Cronback and G. C. Gleser, review of William Stephenson--The Study of Behavior: Q-Technique and Its Methodology, from Psychometrika, Vol. 19, 1954.

Henry F. Kaiser, "The Varimax Criterion for Analytic Rotation in Factor Analysis," Psychometrika, Vol. 23, No. 3, (September, 1958).

Fred N. Kerlinger, Foundations of Behavioral Research: Educational and Psychological Inquiry, (New York: Holt, Rinehart and Winston, Inc., 1964).

Joseph E. Morsh, "The Q-Sort Technique as a Group Measure, "Educational and Psychological Measurements, Vol. XV, No. 4 (Winter, 1955).

William J. Schill, "The Use of the Q-Technique in Determining Curriculum Content," California Journal of Educational Research, XII, No. 4 (Sept. 1961).

M. Stephen Sheldon and A. Garth Sorenson, "On the Use of Q-Technique in Educational Evaluation and Research," Journal of Experimental Education, Vol. 29, No. 2, (December, 1960).

Sidney Siegel, Nonparametric Statistics: For the Behavioral Sciences, (New York: Mcgraw-Hill Book Company, Inc., 1956).

Buford Stefflre, "Analysis of the Inter-Relationships of Rankings of Occupations," Personnel and Guidance Journal, (February, 1959).

Helen M. Walker and Joseph Lev, Statistical Inference, (New York: Holt, Rinehart and Winston, Inc., 1953).

CHAPTER VI

RECOMMENDATIONS

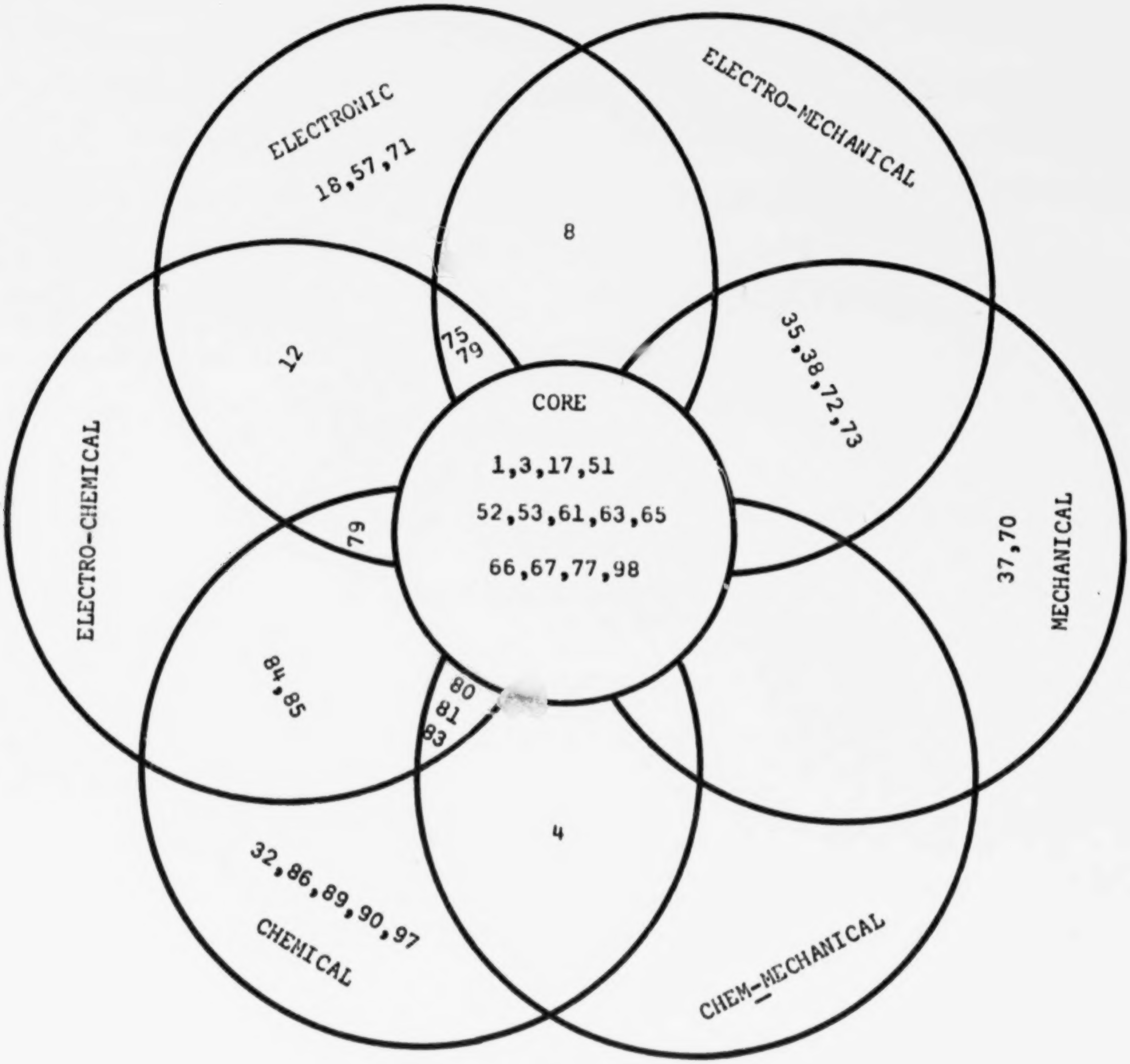
Formal educational activity to prepare technicians is housed in a variety of institutional structures. Public education generally has placed preparation for the technologies in the junior college and private education has developed a number of technical institutes at the post high school level for the same purpose. The diversity of the institutions, offerings, and time spans allotted to this preparation require that the recommendation herein for curricula be of a general nature and not modeled after any one type of technical education offering. There is a temptation to list the knowledges functionally related to all of the technologies studied and the specific knowledges for each in the form of semesters of study. However, the sequence, method, and time allotted for study of any given area is often predicated upon faculty, facilities, and student population. Therefore, the recommendations leave the arrangements of course of study, sequence, and time to the institutions that find this report worthy of consideration when planning their curricula.

The Core Program and Overlapping Knowledges

The following schematic presents the core program and the specific programs for each of the technologies in pictorial form, using the card number from the card sort to identify the knowledges. Data processing, although included in the general core, is not represented in

FIGURE VI-1

Schematic Representation of General and Specific Knowledges Related to Six Technologies


ELECTRONIC
18,57,71
ELECTRO-MECHANICAL
8
12
75
79
35,38,72,73
CORE
1,3,17,51
52,53,61,63,65
66,67,77,98
ELECTRO-CHEMICAL
79
37,70
MECHANICAL
84,85
80
81
83
4
32,86,89,90,97
CHEMICAL
CHEM-MECHANICAL

the specific recommendations because of insufficient number of respondents in that category.

The supervision factor identified earlier is absent from the schematic presented on the preceding page. Supervision is generally not considered to be an entry occupation and therefore may not have a place in programs to prepare technicians for industry. It was however, general across all of the technologies in terms of the knowledges related to supervision. Therefore, the knowledges required for supervision are presented later in this chapter.

The Core Program

The knowledges functionally related to all of the technologies investigated are presented in groups with brief comments on the interpretation and the current use of these knowledges in published recommendations for curricula content.

One item stands alone and it is;

1. Technical and scientific oral and written communication including business forms, reports, emphasizing the different types of business letters. Techniques of collecting and presenting scientific data. Informal reports and formal reports; special types of technical papers.

In technology programs housed in junior colleges it is very common to require the fundamental english composition course as a requirement in the technical curriculum. Inspection of the description above will indicate that this is not a typical english communication course, but is more specific and takes into account the needs for communication in the industrial setting. Similar recommendations are included in recent publications of the U. S. Office of Education[1,2,3,4] and State and local publications[5].

By far the largest number of items included in the general core come from an area typically known as general engineering or as engineering graphics and these items are as follows.

3. Numerical control, data processing, interpretation of engineering drawings, depiction of data by manuscript, minimum dimensions and use of formulae, left data, translation, programming, and quality control.

61. Sketching forms from observation; emphasizing volumes, perspective, composition, and measurements.

63. Machine elements and calculations in determining the size and shape of various machine parts. Factors which influence the selection of materials to be used. Prototypes.

65. Preparation of block diagrams, schematics, and layouts using standard conventions.

66. ASA standards, use of handbooks, graphical treatment of empirical data, conversion charts and nomograms, graphical differentiation and integration, tolerance and limit dimensioning.

67. Projection and graphic representation: use of instruments, lettering, applied geometry, dimensioning, sections, conventions (e.g., welding, pipe, electronic), auxiliary views, screw threads, cams, gears, theory of perspective, preparation of working and assembly drawings.

The inclusion of these six areas of knowledge in the core program accounts for the few number of items being included in the specific knowledges for mechanical technology as shown in Figure VI-1. Graphical presentation of plans, data, and diagrams have long been known as the language of industry and it is herein suggested that they are the language of the technologies within these industries also. The reference cited in footnote 4 above includes recommendations for all of the above areas of knowledge in mechanical technology whereas the other references cited have only selected aspects of these areas suggested for the electrical electronic technologies. Another U. S. Office of Education publication on instrument maintenance suggests most of the above in its curriculum recommendations[6] and then goes beyond the general area to suggest the types of practices that might be involved within the course of study.

In contrast to the publications that are very specific in their recommendations down to details on the method of teaching a subject, there are a number of reports, of which the one cited[7] is an example, that make no explicit recommendations at all.

In the area of mathematics there are three cards that express the general requirements across all technologies. These are as follows.

51. Trigonometric functions and fundamental formulae. Logarithms and solution of triangles, identities and equations. Trigonometry from ratios, right triangles and identities through vectors and graphs of trigonometric functions.

52. Algebraic graphing, exponents, powers, roots, radicals, imaginary and complex numbers through ratio proportions, variations, and logarithms.

53. Metric system and square root; geometry from plane figures to geometric solids; algebra from operations with signed numbers through algebraic expressions, equations, special products, factoring, and fractional equations and simultaneous equations.

Many of the engineers interested in technical education may find this recommendation to be very meager as it isn't uncommon for their recommendations to include the study of mathematics through the calculus. The general requirements here, however, are consistent with past research that the author has done[8].

The remaining three items in the core program are:

17. Use of simple test equipment. Theory and application of commercial test equipment, trouble analysis and test and alignment methods and practices.

77. The use of measuring equipment in a system to measure or control the system; such as thermocouples, strain gauges, pressure transducers and various current or voltage pickups. Accuracy inherent in alternate methods of measurement. Methods of transcribing or indicating measured values, or of using measured quantities to control the system.

98. Environmental testing of components, parts, and products for assessment of performance in actual application.

Most other curriculum recommendations have been more specific in terms of the kinds of measuring instruments and devices that the students should gain knowledge of in their laboratory activities. Modern technology throughout the industries is now using measuring devices that have been previously limited to a specific technology in their assessments. A good example is the use of oscilloscopes in chemical processing, the use of X-ray devices and servo recorders in many types of metal and chemical analysis not to mention their continued use in the area of component testing and systems testing in electronics.

The Specific Knowledges Related to the Six Technologies

One of the more important aspects of the schematic representation of functional knowledges, shown in Figure VI-1, is that the hyphenated technologies, i.e. electro-chemical, electro-mechanical, chemical-mechanical technology, have no unique requirements of their own, but draw upon the technologies that contribute to their hyphenated titles. This in and of itself seems to suggest that it isn't necessary to plan new and specific courses for every technical position that occurs in industry, but rather to regroup the offerings so as to contribute to the technician's ability to call upon the knowledges in basic areas.

Chemical technology appears to be the more independent of the three basic technologies considered herein in that it shares some of the specific knowledges required with electro-chemical technology and chemical-mechanical technology and has only one item in common with electronic technology, that item being the use and calibration of typical industrial and laboratory instruments. The greatest amount of permeation of the other technologies comes from electronics, but this may be a function of a large number of items that conceivably could be included in mechanical-technology having common relationship to all of the technologies investigated and therefore being included in the core program.

To avoid unnecessary redundent statements the areas of electronic, mechanical, and chemical technology will be presented first and the three hyphenated technologies will be presented following with references to the knowledges drawn from the basic technologies.

Electronic Technology

It has generally been conceived that physics is the parent discipline for the area of electronics and there really is no room for debate on this issue, however the kinds of knowledges that electronic technicians identify as being functionally related to their job performance are a specific within the vast domain of physics and are as listed below.

8. Analysis and design of basic electronic circuits involving vacuum-tube and semi-conductor devices. Graphical characteristics and coefficients. Linear equivalent circuits. Elementary feedback analysis.

12. Couloumb's Law and the basic concepts of electrostatics, direct and alternating current theory, magnetism, electromagnetism, Ampere's Law, oscillator circuits, and L/c and R/c circuits.

18. Principles of pulse and timing circuits, including multivibrators, limiters, clippers, blocking oscillators, and counting circuits. Quantitative analysis of differentiating and integrating circuits.

57. Vacuum tube and transistor theory. AC parameters, resonance, transformers, coupling, filters, bandpass, and complex wave forms. Tuned and untuned circuits, and vacuum tube power supplies.

71. Electronic circuit theory of video amplifiers, tuned amplifiers, and basic feedback oscillators. Nonlinear amplifiers, modulators and demodulators. Noise in electron devices. Relaxation phenomena and Wave-form generation.

75. The use of synchros and servomechanisms, synchro generators, motors, differentials and control transformers. Control circuitry for error detection, anti-hunt systems, servo amplifiers, thyratron motor control, the Ward Leonard control systems, the amplidyne, and AC servomotors. Industrial application of electronic controls including photoelectric devices.

79. The calibration and use of typical industrial and laboratory instruments and their actual use in the analysis of equipment representative of various fields. Calorimetric, spectrophotometric, spectrographic, electrolytic, and potentiometric methods.

Chemical Technology

As was mentioned before chemical technology seems to be the more independent of the three basic technologies included in this study and as the consequence it has a greater number of items specifically related to job performance in chemical technology. These items are as follows.

4. Thermosetting and thermoplastic materials. Films, enamels, paints, lacquers, alkyds, phenolics.

32. Elementary techniques and practices of manipulation and fabrication of simple laboratory apparatus of heat resistant glass. Bending, cutting, grinding, pulling, and joining glass.

79. The calibration and use of typical industrial and laboratory instruments and their actual use in the analysis of equipment representative of various fields. Calorimetric, spectrophotometric, spectrographic, electrolytic, and potentiometric methods.

80. The basic laws and theories of elements, compounds, and the structure and behavior.

81. The principles, equipment, operation, and flow of chemical processes. Production of the common acids, bases, salts, gases, and cryogenic liquids.

83. Chemical testing of industrial materials and products; preparation of solutions and reagents; and investigation of gravimetric, volumetric, and gasometric methods. Chromatographic, spectrophotometric, spectrographic, potentiometric, and conductimetric, and microscopic procedures.

84. The fundamental laws governing the behavior of gases, liquids and solutions. Chemical equilibrium in homogeneous and heterogeneous systems. Electrolysis, conductance, transference. EMF's of cells with and without transport. First law of thermodynamics with application to thermochemistry. Application of thermodynamics. Chemical kinetics including photochemistry and chain reactions. Quantum theory and infrared and Roman spectra.

85. Carbon compounds; their structures, properties and nomenclature; types of reactions of important functional groups. Laboratory techniques, preparations and qualitative analysis.

86. The physical chemistry of polymerization, basic kinetics and mechanisms of condensation and addition of polymerizations. The measurement of the physical properties of high polymer systems including molecular weight, solution properties, and polymer structure.

89. Mechanics of fluids, temperature scales, thermal expansion, methods and laws of heat transfer, calorimetry, properties of gases, fusion and vaporization, and an introduction to thermodynamics; wave motion and sound.

90. Atoms, single crystals and polycrystaline materials. Properties of the metallic state; nature of alloys; making of alloys; phase equilibrium diagrams; micro-constituents of alloys; mechanical and thermal treatment; survey of non-ferrous and ferrous metallurgy.

97. Elementary aspects of organic unit processes including nitration, sulfonation, halogenation, hydrogenation, oxidation and alkylation.

Mechanical Technology

Given the foregoing statements that much of what is generally conceived to be mechanical technology is inherent in the recommended core program the specific knowledges functionally related to mechanical technology are shared only by electronic technology. These knowledges are as follows.

35. Metal forming including machining, chemical milling, spinning, electrical forming, and explosive forming.

37. Metal forming including casting, die casting, forging, extruding and the accompanying pattern and tool construction.

38. Applied statics and strength of materials, dealing with forces, stresses, and the design of simple machines and structures. Applications of the characteristics of modern engineering materials to structures.

70. Ferrous and non-ferrous metal heat treating, macrostructure, composition, physical and chemical testing. Metallography, metallurgical examinations, inspection procedures, and corrosion testing.

72. Pattern drafting and layout; tool operations as related to processes of manufacturing sheet and plate products.

73. Metal fabrication including oxyacetylene welding and cutting; electric arc welding; heliarc and shielded arc welding; friction and vacuum welding, and cold fasteners.

Electro-Mechanical Technology

Electro-mechanical technology seems to derive the greater part of its functional knowledge from mechanical technology although it does have three of the set of seven descriptions of knowledge coming from electronic technology. In the interest of brevity only the card numbers will be cited here and those interested readers can refer back to the two basic technologies to identify the knowledges functionally related to electro-mechanical technology. The card numbers are 8, 35, 38, 72, 73, 75, and 79.

Electro-Chemical Technology

Of the seven items functionally related to job performance of the electro-chemical technicians, five of them come from chemical technology and two from electronic technology. One of the ones from electronic technology (item 12) is a very fundamental concept in electrical theory and the other (item 79) is the use of instruments developed in electronic technology that have application in the chemical technologies. Again to avoid redundance the items from chemical technology that are functionally related to this sub group of technicians in addition to the two mentioned above are 80, 81, 83, 84, and 85.

Chemical-Mechanical Technology

Chemical-mechanical technology derives sufficient background in mechanical technology from the core program and consequently shares all the items from the more independent chemical technology in its knowledges functionally related to job performance. These items are 4, 80, 81, and 83.

Supervision

In the jargon of vocational education the items suggested herein as being functionally related to the more advanced positions in all of the six technologies would be called job enlargement or upgrading whereas in the typical junior college structure, at least three of the seven items recommended here would be included in the traditional academic offering. These three would be:

26. Practical application of basic psychology in planning, conducting and evaluating conferences and interviews. Emphasis on employee selection, classification, training, evaluation, working conditions, counseling, group attitudes in the occupational situation as they affect motivation, status and morale.

28. Maintaining labor force and control so that the objectives and purposes of the company are attained as effectively and economically as possible. Methods and procedures related to the efficient utilization of resources in production; specialization of process and labor; product and process analysis, production planning and control; materials procurement and control; methods improvement; time study and wage determination; selection of layout, etc.

30. Basic principles underlying human behavior and its control; perception, learning, motivation, emotion, intelligence, personality and adjustment.

The remainder of the items would more typically come in advanced study at college, but are suggested here to be of value to occupational mobility and should be considered to be offered in adult education at the less than degree status colleges. These are:

23. Organization and methods involved in establishment and conduct of training programs for company employees.

27. Time study and the science of management; process charts, operation analysis, motion economy and job design; time study preparation, observation, calculation and adjustment; ration delay study; formula development and construction of tables, curves and multivariable charts.

42. Cost accounting, job-lot process cost. Accounting methods for material, labor and factory overhead, and preparation of financial statements from cost data.

44. (PERT) Selection and sequencing of specific identifiable events necessary to successful completion of a project. Estimates of time, evaluation procedures, information channels, and use of data processing techniques to permit periodic summaries of projects.

Of the curriculum recommendations reviewed by the author, the one that most nearly approximates recommendations herein for supervision was a manpower report on electronic business data processing[9].

Summary

The core program and the specific programs for the six technologies embrace a total of 37 card sort items which could be conceived as course descriptions. To be able to offer programs in six technologies with a total of 37 courses, many of which would be included in the basic academic offerings of a junior college, takes a considerable burden off of the typical post high school educational institutional in that each and every technology does not require a complete unique curriculum of its own.

FOOTNOTES

1. Electrical Technology, U. S. Department of Health, Education, and Welfare, (Washington: 1960), pp. 36.

2. Electronic Technology, U. S. Department of Health, Education, and Welfare, (Washington: 1960), pp. 36.

3. Electronic Data Processing-I, U. S. Department of Health, Education, and Welfare, (Washington: 1963), pp. 20.

4. Mechanical Technology: Design and Production, U. S. Department of Health, Education, and Welfare, (Washington: 1962), pp. 62.

5. Electronic Technology, Illinois Board of Vocational Education and the University of Illinois, 1964, pp. 52.

6. Course in Instrument Maintenance, U. S. Department of Health, Education, and Welfare, (Washington: 1963), pp. 43.

7. Christy Murphy, Technician Need Study: Vermilion County Illinois, Department of General Engineering, (Danville: Interstate Printers & Publishers, Inc., 1964).

8. Melvin L. Barlow and William John Schill, The Role of Mathematics in Electrical-Electronic Technology, (University of California: 1962).

9. Electronic Business Data Processing, Manpower Development and Training Program, U. S. Department of Health, Education, and Welfare, (Washington: 1964), pp. 39-41.

CHAPTER VII*

SUMMARY

The rapid changes that have taken place in the working world as a result of technological and sociological evolution have laid the groundwork for a new occupational grouping. This has been named the technical occupations.

The requirements necessary to gain entry into the occupational setting have been rising. Incorporated into the knowledge necessary to fulfill the functions of the occupations is an increasing reliance upon the physical, natural, and mathematical sciences upon which industry is predicated. Even with the postponed entry into the labor field, there is insufficient time for an engineer or scientist to master both the abstract scientific concepts which contribute to the development of new processes, and the techniques and practical application of those concepts in the production setting. At the same time the craftsman and the skilled operators need to concentrate on mastering the machine processes necessary for ultimate production.

Hence, there arises a large gap between abstract engineering and production. The technician finds himself trying to bridge this gap. He must have the basic knowledge to communicate with the engineer and scientist; in addition he must have a working knowledge of the production setup in order to facilitate the construction of prototypes and the assessment of theoretical or abstract physical science phenomena directed toward the production of consumable products.

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* This chapter was prepared by Barbara Rosenquist.

Real understanding of the place of the technician in current industrial society requires a rethinking of the entire industrial process and organization. The definition of the technician cannot be predicated upon some past concept of occupational classification. For the purposes of this project, the definition used was the one proposed by the President's Committee on Scientists and Engineers.

A cursory examination of the curricula in various institutions designed to prepare technicians must result in the conclusion that the training programs for any specific technology have little similarity. Now that research has been completed on the basic terms, occupational groupings, and areas of manpower needs, it is time to identify more precisely the curricula content common to a variety of technical training programs. The current shortage of technicians and industries preference for personnel trained in the armed forces serve as mute evidence that current and past practices of determining curriculum content are less than satisfactory.

Procedure

The distribution of manpower (current and predicted) by age group and occupational classification for the State of Illinois is very similar to that of the United States as a whole. The distribution of employees among the census categories for manufacture in Illinois approximate that of the United States for 16 of the 20 categories.

One of the basic concerns of the project was to be as representative of industries and their technicians as possible. To give representation, a random selection procedure was utilized. The universe of manufactures was supplied by the Illinois Employment Security Administration. To obtain the random sample of 500 establishments every thirteenth establishment, employing over 20 personnel,was selected from the excess of 6000 establishments in the universe.

Chi-square was used to compare the sample thus selected with the universe on variables that could have had a biasing effect. The results showed no significant differences. The sample was also tested via Chi-square on three important variables, the results indicated that type of manufacture is related to geographic location in the state.

Personal contacts and interviews were used to ascertain whether or not the establishment employed technicians as per the projects adopted definition of technician. One hundred eighteen establishments did employ technicians and 382 did not. Chi-square analysis of the confirmed and rejected establishments indicated that size of the establishments labor force is related to employing technicians as is production planning and research.

In recognition of the obvious fact that technicians perform a variety of functions, a concerted effort was made to interview men in each technician classification at each of the establishments. The study was designed to retain representativeness without overburdening any of the selected establishments.

An interesting observation uncovered during the interviews was the lack of management information concerning the job functions and educational background of their employees. This served to support one of the basic tenets of this research, "to find out what a technician does and what knowledges are related to his job the place to go is to the employed technician."

Instruments

The basic instrument used to collect data on the knowledges related to technical occupations was a modified version of the Q-sort technique, referred to here as a card sort. A group of cards was developed to represent the content of courses taken by technicians in preparation for various jobs. Each card had on it a brief description of a course, developed to approximate the course content of most technical institutes. The validity of the cards was assessed by a panel of experts and a series of three pilot studies, thereby assuring their understandability and coverage among the areas.

In order to cover the wide range of knowledges which could conceivably be functionally related to job performance in the numerous technologies, the number of cards found to be totally unrelated to any specific technology approximated 1/3 of the total. This was the prime reason for modifying the Q-sort technique. In this study respondents initially sorted the cards into three piles (those closely related to job performance, those somewhat related and those totally unrelated) and then forced the related and somewhat related piles into the left end of a normal distribution.

The technique of having individuals respond to a set of cards, has a number of advantages over the rating form which is more typically used. The most obvious of these are the opportunity to compare all of the items with each other in the process of responding and the opportunity to make assessments of the relatedness of items without being committed to a given response until all items have been inspected and reviewed.

In addition to the card sort, each respondent was interviewed individually. The data collected in the interview served to provide background information on each technician and to provide information about the current position which was essential to the card sort analysis.

Results, Conclusions and Recommendations

The analysis of the information gathered during the interviews afforded some interesting insights into the job patterns of the technicians. The reasons for taking a job varied according to where the job fell in the career pattern. First jobs were taken primarily for monetary reasons, through the influence of friends or family or for their close proximity to home. As the respondent gained experience, his job mobility was likely to be predicated on aspirations for advancement, responsibility, and/or security.

Assessing the educational attainment of the respondents helped to clarify some of managements viewpoints concerning hiring practices. The type of program pursued in high school was found to be related to the level of employment on the first job. The traditional college directed program, with its emphasis on science and mathematics, is more in line with the needs of the technician positions than is the occupationally oriented program with its emphasis on the crafts. However, it is further noted that the first job does not necessarily relate to the ongoing career pattern of the respondent. This is another reason for challenging the vocational offerings at the high school level. It would seem that educational attainment is used advantageously to gain entry into a position, but thereafter, advancement is based on job achievement.

The coefficient of concordance (W), Kruskal-Wallis one way analysis of variance (H), and principal components factor analysis were used to identify the core program and to identify the specific areas of knowledge related to the separate technologies.

The statistics demonstrated strong general agreement on the placement of the items across technologies. This agreement was further verified by partialing on possible confounding variables.

It is recognized that in using this process, the respondents with supervisory positions or positions requiring extended experience had an inflationary effect on the amount of knowledge functionally related to job performance. This seems acceptable considering vocational-technical education's aspirations to prepare students for both entry and progress within their chosen occupations.

The knowledges functionally related to all the technologies (the core program) were found to include technical writing, engineering graphics, mathematics through trigonometry, and the use of test equipment.

This study concludes that many of the requirements of technology are included in the academic offerings of the typical junior college. This should take much of the burden off post high school educational institutions since each technology does not require a complete and separate curriculum, it can share aspects of its curricula with other technologies and it can also share in selected aspects of the current academic offerings.

FORM A

Scale for Determining Technicians to be Interviewed

It is the hope of the Research personnel that the following scale can be adhered to in selecting technical personnel at random from the total population of technical workers of the manufacturing industries in our sample. The scale as it is defined below is intended to give us a sufficient sample of the various job categories in which technical workers are employed without causing undue hardship to any of the employers:

Total No. of Tech. Empl.	No. to be Drawn at Random for Interviewing
1	1
2	2
3	3
4 - 7	4
8 - 10	5
11 - 13	6
14 - 16	7
17 - 20	8
21 - 25	9
26 - 30	10
31 - 40	11
41 - 50	12
51 - 75	13
76 - 100	14
101 and above	15

FORM B

PRELIMINARY SORT REPORTING FORM

ID__________________________

For the two smaller stacks of cards, record the number of each card under its appropriate heading. Beyond getting each card into one of the three groups, the order of writing them down is unimportant.

Related	Somewhat Related	Unrelated
___ ___ ___ ___	___ ___ ___ ___	___ ___ ___ ___
___ ___ ___ ___	___ ___ ___ ___	___ ___ ___ ___
___ ___ ___ ___	___ ___ ___ ___	___ ___ ___ ___
___ ___ ___ ___	___ ___ ___ ___	___ ___ ___ ___
___ ___ ___ ___	___ ___ ___ ___	___ ___ ___ ___
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___ ___ ___ ___	___ ___ ___ ___	___ ___ ___ ___
___ ___ ___ ___	___ ___ ___ ___	___ ___ ___ ___

FORM C
Q-SORT REPORTING FORM

ID____________________

Each card has an identification number in the upper right hand corner. List the number on each card in the proper group below.

					____					
				____	____	____				
				____	____	____				
			____	____	____	____	____			
			____	____	____	____	____			
			____	____	____	____	____			
			____	____	____	____	____			
		____	____	____	____	____	____	____		
		____	____	____	____	____	____	____		
		____	____	____	____	____	____	____		
	____	____	____	____	____	____	____	____	____	
	____	____	____	____	____	____	____	____	____	
____	____	____	____	____	____	____	____	____	____	____
____	____	____	____	____	____	____	____	____	____	____
____	____	____	____	____	____	____	____	____	____	____
3	5	8	12	14	15	14	12	8	5	3
(7)	(6)	(5)	(4)	(3)	(2)	(1)	(0)	(0)	(0)	(0)

Most Related Least Related

FORM D

CODE

Sex
1 = male
2 = female

Race
1 = White
2 = Negro
3 = Other non-white

Geographic
1 = Chicago (Will, DuPage, Cook, Kane, McHenry)
2 = Downstate Metro (Winnebago, Rock Island, Peoria, Macon, Tazewell, Sangamon, Madison, Champaign, St. Clair)
3 = Downstate Rural
4 = Outside State
5 = Outside U. S.

Source (1)
0=other
1=pub sch
2=prvt sch
3=mil sch
4=co sch
5=OJT
6=appren'ship
7=self study
8=cooperative
9=correspon

Ed'l Attain. in semester hrs.

Length of Time in months

H.S. Diploma
1=none
2=regular
3=G.E.D.
4=other

Major Area (3)
0=none
1=mathematical sci
2=physical sci
3=biological sci
4=business & mgmt
5=general
6=bldg trades
7=elect trades
8=mach trades
9=printing trades
10=art
11=home ec
12=ag
13=engr
14=engr mech
15=air frame & power mech
16=drafting trades
17=appliance repairs
18=liberal arts
19=data processing

Mfg Area Code
00=other than mfg
10=ordinance & access
20=food & kindred prod
21=tobacco mfrs
22=textile mill prod
23=apparel & other fin prod made fr fabric & sim mat
24=lumber & wood prod except furn
25=furn & fix
26=paper & appl pr
27=pr,publ,&alld pr
28=chem & alld prod
29=petrol ref & alld industries
30=rubber & misc plas products
31=leather & lther pr
32=stone, clay, & glass prod
33=primary metal ind
34=fabri metal prod except ordinance mach & trans equip
35=mach, non-elec
36=el mach, equip & suppl
37=transpt equip
38=prof, sci & control instrumts, photo, optical & watches
39=misc mfg indus

Reason for Taking Job
01=none
02=lay off
03=fired
04=circumstantial
05=personal
06=money
07=responsibility
08=geogr
09=interest
10=status
11=available trng
12=influ of friend
13=influ of family
14=influ of teacher
15=military service
16=other
17=opport for advan
18=security
19=opport for exper
20=prvt emp service

SES
1=no
2=yes
3=yes w/test

Mobility
1=downward (within)
2=downward (without)
3=horizontal (w/in)
4=horizontal (w/out)
5=stable
6=upward (within)
7=upward (without)

Mgmt Level
3 = 3 lev
2 = 2 lev
1 = 1 lev
0 = tech lev

Level of Employ (1)
1 = management
2 = professional
3 = technical
4 = skilled
5 = semi-skilled
6 = unskilled
7 = domestic
8 = farm labor
9 = other

General Area of Employ (2)
0 = other
1 = R & D
2 = sales
3 = production
4 = maintenance

Level w/Gen Area of Empl (3)
0 = other
1 = engr tech or abstract
2 = ind tech or prototype
3 = specialist or repetive
4 = supervision

Program
0 = other
1 = general
2 = college directed
3 = occupational
4 = avocational

Resp f Tech
1 = no
2 = yes

FORM E

CURRICULAR RESEARCH

Identification:
I.D.__/__Company I.D.__/__/__
Age__/__Sex__
Place of Birth__ Race__

1. Educational History

A. H.S. Location__, Diploma__
Source__Program__Maj Area__/__

B. Post H.S. Loc__, Source__,
Prog__, Maj Area__/__
WkDay__/__/__,SemHrs__/__/__

C. Post H.S. Loc__, Source__,
Prog__, Maj Area__/__
WkDay__/__/__,SemHrs__/__/__

D. Post H.S. Loc__, Source__,
Prog__, Maj Area__/__
WkDay__/__/__,SemHrs__/__/__

E. Post H.S. Loc__, Source__,
Prog__, Maj Area__/__
WkDay__/__/__,SemHrs__/__/__

F. Comments on Education________
____

G. Educat'nl Attn'ment__/__/__

2. Job History

A. Location__, Length__/__/__
Related Sch__/__/__/__Sal__/__
Reason for taking this job__/__
SES__Area of Mfg__/__
Lvl of Empl__Gen Area of Empl__
Lvl w/in Area of Empl__

B. Location__, Length__/__/__
Related Sch__/__/__/__Sal__/__
Reason for taking this job__/__
SES__Area of Mfg__/__Mob__
Lvl of Empl__Gen Area of Empl__
Lvl w/in Area of Empl__

C. Location__, Length__/__/__
Related Sch__/__/__/__Sal__/__
Reason for taking this job__/__
SES__Area of Mfg__/__Mob__
Lvl of Empl__Gen Area of Empl__
Lvl w/in Area of Empl__

D. Location__, Length__/__/__
Related Sch__/__/__/__Sal__/__
Reason for taking this job__/__
SES__Area of Mfg__/__Mob__
Lvl of Empl__Gen Area of Empl__
Lvl w/in Area of Empl__

E. Location__, Length__/__/__
Related Sch__/__/__/__Sal__/__
Reason for taking this job__/__
SES__Area of Mfg__/__Mob__
Lvl of Empl__Gen Area of Empl__
Lvl w/in Area of Empl__

F. Location__, Length__/__/__
Related Sch__/__/__/__Sal__/__
Reason for taking this job__/__
SES__Area of Mfg__/__Mob__
Lvl of Empl__Gen Area of Empl__
Lvl w/in Area of Empl__

G. Location__, Length__/__/__
Related Sch__/__/__/__Sal__/__
Reason for taking this job__/__
SES__Area of Mfg__/__Mob__
Lvl of Empl__Gen Area of Empl__
Lvl w/in Area of Empl__

H. Location__, Length__/__/__
Related Sch__/__/__/__Sal__/__
Reason for taking this job__/__
SES__Area of Mfg__/__Mob__
Lvl of Empl__Gen Area of Empl__
Lvl w/in Area of Empl__

I. Comments on Job History________
____
____

3. Current Job

Location__, Length__/__/__
Related Sch__/__/__/__Sal__/__
Reason for taking this job__/__
SES__Area of Mfg__/__Mob__
Lvl of Empl__Gen Area of Empl__
Lvl w/in Area of Empl__

Comments on Present Job________
____
____
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____

Form F

Salary Code Card

Annually

01 = under 4000
02 = 4001 to 4500
03 = 4501 to 5000
04 = 5001 to 5500
05 = 5501 to 6000
06 = 6001 to 6500
07 = 6501 to 7000
08 = 7001 to 7500
09 = 7501 to 8000
10 = 8001 to 8500
11 = 8501 to 9000
12 = 9001 to 9500
13 = 9501 to 10,000
14 = 10,001 to 10,500
15 = 10,501 to 11,000
16 = 11,001 to 11,500
17 = 11,501 to 12,000
18 = 12,001 to 12,500
19 = 12,501 to 13,000
20 = 13,001 to 13,500
21 = 13,501 and above

Weekly

01 = under 77
02 = 77.01 to 86
03 = 86.01 to 96
04 = 96.01 to 106
05 =106.01 to 115
06 =115.01 to 125
07 =125.01 to 134
08 =134.01 to 144
09 =144.01 to 154
10 =154.01 to 163
11 =163.01 to 173
12 =173.01 to 182
13 =182.01 to 192
14 =192.01 to 202
15 =202.01 to 212
16 =212.01 to 221
17 =221.01 to 231
18 =231.01 to 240
19 =240.01 to 249
20 =249.01 to 260
21 =260.01 and above

FORM G

DIRECTIONS FOR THE Q-SORT

Each of the cards in the deck of cards you have been given describes an area of knowledge or skills. The cards are to be sorted according to the extent to which the descriptions on them are related to the successful performance of your job. Do not concern yourself with logical order or prerequisite knowledge. To do this most readily, the following procedures would be useful:

1. Read through all the cards to become familiar with the material.
2. Sort the cards into three groups:
   a. one group of cards which describe knowledges and skills that are most essential to successful job performance: Related
   b. one group of cards about which you are in doubt: Somewhat Related
   c. one group of cards which describes knowledges and skills which are least essential to successful job performance: Unrelated
3. Record the numbers of these cards on the sheet supplied.
4. To execute the final distribution begin with the cards most important to successful performance of your job. Read through and select the three most important and place them in one pile; then select the five next in importance, place them in the second pile, etc. Continue this procedure until you have exhausted the cards from the original related and somewhat related piles.
5. After you have sorted the cards, check carefully your whole distribution to be sure that you have made no mistakes. Make certain that your sort follows the distribution indicated.
6. Please report your sortings on the form supplied.

FORM H

Card Content

(1) Technical and scientific oral and written communication including business forms, reports, emphasizing the different types of business letters. Techniques of collecting and presenting scientific data. Informal reports and formal reports; special types of technical papers.

(2) Fundamental physical and chemical principles governing food preservation by freezing, canning, drying, concentration, salting, smoking, fermenting, carbonating.

(3) Numerical control, data processing, interpretation of engineering drawings, depiction of data by manuscript, minimum dimensions and use of formulae, left data, translation, programming, and quality control.

(4) Thermosetting and thermoplastic materials. Films, enamels, paints, lacquers, alkyds, phenolics.

(5) The biology of the common bacteria and microorganisms. Laboratory work in the techniques of sterilization, disinfection; isolation and maintenance of pure cultures; staining and identification.

(6) Lab procedure to identify and protect against radiation and electrical hazard including medical and nursing methods.

(7) Relationships between the structure and the physical and chemical properties of ceramic materials, including clays, refractories, and cement.

(8) Analysis and design of basic electronic circuits involving vacuum-tube and semi-conductor devices. Graphical characteristics and coefficients. Linear equivalent circuits. Elementary feedback analysis.

(9) The chemistry of food; carbohydrates, protein, fats, minerals, vitamins, and food pigments. Basic nutritional needs.

(10) Mendelism, the chromosomal theory, the physic-chemical nature of the gene, cytoplasmic inheritance and environmental influences; emphasis on human inheritance, problems of genetic counseling, and eugenics; experiments with fruit flies, protozoa and plants.

(11) The constellations, solar system, structure of the universe, determination of time and calendars. Use of astronomical instruments for data collection.

(12) Coulomb's Law and the basic concepts of electrostatics, direct and alternating current theory, magnetism, electromagnetism, Ampere's Law, oscillator circuits, and L/c and R/c circuits.

(13) Agglutination, planting, and transplanting of cultures; animal inoculations; preparations of smears and media utilizing bacteriological material and mycological material from patients. Diagnostic procedure for identification of pathogenic bacteria and fungi. Antibiotic sensitivity studies.

(14) Microbial life with emphasis on morphology, culture, and the biochemical activities of bacteria, viruses and fungi; pathogenic microorganisms, human protozoan and helminth parasites; antiseptics, disinfectants, sterilization, infection and resistance, diagnostic tests and immunizations.

(15) Laboratory techniques in use for identification of parasites. Thick film for malaria, concentration techniques for ova and cysts, wet and stained preparations for intestinal parasites, especially of the common pathological forms.

(16) General and economic entomology; taxonomy of the principal orders in insects; life histories, habits, recognition, and control of some of the principal insect pests.

(17) Use of simple test equipment. Theory and application of commercial test equipment, trouble analysis and test and alignment methods and practices.

(18) Principles of pulse and timing circuits, including multivibrators, limiters, clippers, blocking oscillators, and counting circuits. Quantitative analysis of differentiating and integrating circuits.

(19) Mineralogy including physical properties, blowpipe and chemical methods; the origin occurrence and association of minerals; basic crystallography, and the identification of minerals by means of physical and chemical properties.

(20) Identification and classification of minerals and rocks with particular emphasis on well cuttings, field mapping, subsurface mapping and well correlation. Historical geology, geophysical methods, and electric log interpretation. Rotary drilling equipment, prime movers circulation systems derricks and masts, bits, lubrication, drilling technique, and mud control and drilling problems.

(21) Thermodynamic aspects of gas turbine and turbo-jet engine design. Perfect and real gas relationships and their application to problems of flow through compressors and turbines. Modern gas turbine cycles and their application to power plant, industrial, and aircraft installations.

(22) Engine cycles, performance, characteristics, analysis of problems, theory of internal combusion engines. Fuel systems on internal combustion engines and the functions of the parts.

(23) Organization and methods involved in establishment and conduct of training programs for company employees.

(24) Analysis of organizational structure of business.

(25) Development of the labor movement and the main forces underlying the labor problem. Government regulation of labor relationships, approach of workers to labor problems; the development of the National Labor Relation Acts, the Wagner Act, the Taft-Hartley Act; management-labor relations.

(26) Practical application of basic psychology in planning, conducting and evaluating conferences and interviews. Emphasis on employee selection, classification, training, evaluation, working conditions, counseling, group attitudes in the occupational situation as they affect motivation, status and morale.

(27) Time study and the science of management; process charts, operation analysis, motion economy and job design; time study preparation, observation, calculation and adjustment; ration delay study; formula development and construction of tables, curves and multivariable charts.

(28) Maintaining labor force and control so that the objectives and purposes of the company are attained as effectively and economically as possible. Methods and procedures related to the efficient utilization of resources in production; specialization of process and labor; product and process analysis, production planning and control; materials procurement and control; methods improvement; time study and wage determination; selection of layout, etc.

(29) The underlying principles of plane surveying; surveying instruments and their use; adjustment of the level and transit; calculations; introduction to mapping and optical tooling.

(30) Basic principles underlying human behavior and its control; perception, learning, motivation, emotion, intelligence, personality and adjustment.

(31) Automotive fuels, fuel requirements, fuel ratings, fuel tanks, lines, fittings, pumps, carburetors, fuel injectors, superchargers, governors, gauges, manifolds, and exhaust systems; automotive batteries, generators, alternators, rectifiers, current regulators, cranking motors, ignition systems, lighting systems, signaling devices, wiring, power windows, and convertible top electrical apparatus.

(32) Elementary techniques and practices of manipulation and fabrication of simple laboratory apparatus of heat resistant glass. Bending, cutting, grinding, pulling, and joining glass.

(33) Tension and compression within the elastic range. Hooke's Law, working assembly, and thermal stresses. Mohr's circle, bending moment and shear diagrams. Deflection of transversely loaded beams. Theory of columns. Combined loadings. Laboratory tests.

(34) Composition and resolution of forces, equilibrium conditions, Newton's laws of motion, uniformly accelerated motion, projectile motion, concept of work, power and energy, elasticity, rotational motion, and simple harmonic motion.

(35) Metal forming including machining, chemical milling, spinning, electrical forming, and explosive forming.

(36) Kinematics of a particle, kinetics of rigid bodies, moments in inertia of masses, rotation of rigid bodies, any plane motion of rigid bodies, impulse, momentum, impact, properties of solids and liquids, and introduction to vector analysis.

(37) Metal forming including casting, die casting, forging, extruding and the accompanying pattern and tool construction.

(38) Applied statics and strength of materials, dealing with forces, stresses, and the design of simple machines and structures. Applications of the characteristics of modern engineering materials to structures.

(39) The physical and chemical fundamentals of glasses. The roles of constituents in relation to the formation, structure and properties of glasses. Basic concepts in the glassy state.

(40) Fundamentals of propulsion. Thermodynamic cycles and basic characteristics of ram jets, turbo jets, turbo props, pulse jets and rockets; analysis of propulsion systems.

(41) Functions and manipulation of the basic business machines, with emphasis on the various duplicating processes and dictaphone machines. Some working knowledge of the comptometer, the 10-key and other calculator and adding machines.

(42) Cost accounting, job-lot process cost. Accounting methods for material, labor and factory overhead, and preparation of financial statements from cost data.

(43) Tax laws as they affect business and accounting procedures; preparation of personal, partnership, and corporate income tax returns; computation of capital stock, excess profits, estate, gift and excise taxes.

(44) (PERT) Selection and sequencing of specific identifiable events necessary to successful completion of a project. Estimates of time, evaluation procedures, information channels, and use of data processing techniques to permit periodic summaries of projects.

(45) Techniques in presenting market data, evaluating market potential, and selecting locations for wholesale, retail, and service establishments.

(46) A branch of mathematics dealing chiefly with the rate of change of functions with respect to their variables--differential calculus.

(47) Graphical solution of problems involving points, lines, planes, revolutions, intersections, angles, tangent planes and developments. Plus problems involving contoured and warped surfaces.

(48) Cartesian and polar coordinates, straight lines, conics, reduction of general quadratics to type forms, locus problems, parametric equations.

(49) Differential equations; line integrals; vector analysis gradient, divergence and curl; solutions of the equations. Partial differential equations and boundary value problems, wave equation, heat conduction, complex variable theory and conformal mapping. Couchy integral theorem, residue theorem.

(50) Separation of variables, homogeneous functions, exact equations, integrating factors, linear equations of the first order first degree, Bernoulli's equations, coefficients linear in the two variables, series integration, orthogonal trajectories, hyperbolic functions and applications.

(51) Trigonometric functions and fundamental formulae. Logarithms and solution of triangles, identities and equations. Trigonometry from ratios, right triangles and identities through vectors and graphs of trigonometric functions.

(52) Algebraic graphing, exponents, powers, roots, radicals, imaginary and complex numbers through ratio proportions, variations, and logarithms.

(53) Metric system and square root; geometry from plane figures to geometric solids; algebra from operations with signed numbers through algebraic expressions, equations, special products, factoring, and fractional equations and simultaneous equations.

(54) Permutations, combinations and probabilities; infinite series; determinants; inequalities, and mathematical induction.

(55) Laplace transforms, Gamma, Bessel and Legendre functions; Fourier series and orthogonal functions; multiple, line and surface integrals; vector field theory, theorems of Gauss, Green, and Stokes.

(56) Linear, radical, and quadratic equations; simultaneous solutions of second-degree equations; binomial theorems, deMoivre's theorem, rational and irrational roots of polynomial equations of any degree; complex numbers, cubic and quadratic equations, theorems on roots, isolation, limits and approximation of real roots.

(57) Vacuum tube and transistor theory. AC parameters, resonance, transformers, coupling, filters, bandpass, and complex wave forms. Tuned and untuned circuits, and vacuum tube power supplies.

(58) Elementary logic, mathematical induction, permutations, combinations probability, the theory of matrices and matrix transformations, theory of vector spaces, and the concept of set.

(59) Integration as the converse of differentiation, integrals as the limit of a sum, reduction of type forms; applications to geometry and mechanics.

(60) Analytic geometry, extremal problems limits, continuity, derivatives, antiderivatives, and the calculation of area by approximation methods and by use of antiderivative functions.

(61) Sketching forms from observation; emphasizing volumes, perspective, composition, and measurements.

(62) Preparation of zoological and botanical materials for microscopic examination; including principal techniques and histochemical preparations.

(63) Machine elements and calculations in determining the size and shape of various machine parts. Factors which influence the selection of materials to be used. Prototypes.

(64) Basic illustrating techniques, color concepts, organization of space and aesthetic judgment.

(65) Preparation of block diagrams, schematics, and layouts using standard conventions.

(66) ASA standards, use of handbooks, graphical treatment of empirical data, conversion charts and nomograms, graphical differentiation and integration, tolerance and limit dimensioning.

(67) Projection and graphic representation: use of instruments, lettering, applied geometry, dimensioning, sections, conventions (e.g., welding, pipe, electronic), auxiliary views, screw threads, cams, gears, theory of perspective, preparation of working and assembly drawings.

(68) Programming of electronic digital computers for applications in business and industry. Data processing, characteristics of computers, and computer programming or coding. Machine organization, problem formulation, automatic programming, numerical analysis, machine language programming, and applications of computers.

(69) The organization and basic operation of a digital computer. Programming, number systems, and Boolean Algebra. Analysis, design, and utilization of principle computer circuits such as logic gates, flip-flops, and memory networks. Design of binary counters and application of Boolean Algebra to perform binary arithmetic.

(70) Ferrous and non-ferrous metal heat treating, macrostructure, composition, physical and chemical testing. Metallography, metallurgical examinations, inspection procedures, and corrosion testing.

(71) Electronic circuit theory of video amplifiers, tuned amplifiers, and basic feedback oscillators. Nonlinear amplifiers, modulators and demodulators. Noise in electron devices. Relaxation phenomena and Wave-form generation.

(72) Pattern drafting and layout; tool operations as related to processes of manufacturing sheet and plate products.

(73) Metal fabrication including oxyacetylene welding and cutting; electric arc welding; heliarc and shielded arc welding; friction and vacuum welding, and cold fasteners.

(74) Plants morphology, physiology, genetic, inheritance, identification, classification, and environmental relationships.

(75) The use of synchros and servomechanisms, synchro generators, motors, differentials and control transformers. Control circuitry for error detection, anti-hunt systems, servo amplifiers, thyratron motor control, the Ward Leonard control systems, the amplidyne, and AC servomotors. Industrial application of electronic controls including photoelectric devices.

(76) Feedback problem in linear systems. Techniques such as: transfer and weighting functions; block diagrams, signal flow graphs, time-domain analysis, root locus technique and frequency-domain analysis.

(77) The use of measuring equipment in a system to measure or control the system; such as thermocouples, strain gauges, pressure transducers and various current or voltage pickups. Accuracy inherent in alternate methods of measurement. Methods of transcribing or indicating measured values, or of using measured quantities to control the system.

(78) The growth and development of dairying. (A) Principles and practices in the production of milk; basic feeding, management, and disease control practices. (B) Basic principles of dairy industry practices; common dairy tests; general survey of all important branches of the industry.

(79) The calibration and use of typical industrial and laboratory instruments and their actual use in the analysis of equipment representative of various fields. Calorimetric, spectrophotometric, spectrographic, electrolytic, and potentiometric methods.

(80) The basic laws and theories of elements, compounds, and the structure and behavior.

(81) The principles, equipment, operation, and flow of chemical processes. Production of the common acids, bases, salts, gases, and cryogenic liquids.

(82) Basic photography with emphasis on graphic arts procedures and applications in the preparation of negatives for offset lithography, basic photographic materials and supplies, developer reaction, color sensitive materials and supplies; and filters and halftone screens.

(83) Chemical testing of industrial materials and products; preparation of solutions and reagents; and investigation of gravimetric, volumetric, and gasometric methods. Chromatographic, spectrophotometric, spectrographic, potentiometric, and conductimetric, and microscopic procedures.

(84) The fundamental laws governing the behavior of gases, liquids and solutions. Chemical equilibrium in homogeneous and heterogeneous systems. Electrolysis, conductance, transference. EMF's of cells with and without transport. First law of thermodynamics with application to thermochemistry. Application of thermodynamics. Chemical kinetics including photochemistry and chain reactions. Quantum theory and infrared and Roman spectra

(85) Carbon compounds; their structures, properties and nomenclature; types of reactions of important functional groups. Laboratory techniques, preparations and qualitative analysis.

(86) The physical chemistry of polymerization, basic kinetics and mechanisms of condensation and addition of polymerizations. The measurement of the physical properties of high polymer systems including molecular weight, solution properties, and polymer structure.

(87) Technique of venepuncture. Practice in the common biochemical medical tests (blood sugar, non-protein nitrogen, proteinometry, etc.) and the uncommon tests (e.g. sodium, potassium, phosphatases, etc.) Liver and kidney function tests, simple toxicological tests, pregnancy tests.

(88) The problems and effects of industrial wastes discharge upon a sewerage collection system and treatment plants to which it is tributary. Industrial wastes ordinances and representative control problems.

(89) Mechanics of fluids, temperature scales, thermal expansion, methods and laws of heat transfer, calorimetry, properties of gases, fusion and vaporization, and an introduction to thermodynamics; wave motion and sound.

(90) Atoms, single crystals and polycrystaline materials. Properties of the metallic state; nature of alloys; making of alloys; phase equilibrium diagrams; micro-constituents of alloys; mechanical and thermal treatment; survey of non-ferrous and ferrous metallurgy.

(91) Equations of state, the first and second laws of thermodynamics, reversible and irreversible processes, isothermal and adiabatic processes, Carnot processes, absolute temperature scale, entropy, free energy, Gibbs potential, equilibrium, Nerst's heat theorem, specific heats of solids.

(92) The properties of fluid and vapors including use of vapor tables and charts: flow of fluids in nozzles; combustion calculations; vapor cycles and steam power applications; mixtures of vapor and gases.

(93) The principles and practice of heat transfer by conduction, radiation, free and forced convection, vapor condensation, and boiling liquids. Unsteadystate heat transfer.

(94) Fission, neutron diffusion, neutron moderation, bare homogeneous thermal reaction, Reactor Theory, special relativity, x-rays, nuclear structure, natural and artificial transmutation, and radioactivity.

(95) The nature and propagation of light, photometry, diffraction and interference, dispersion, spectra and color, polarized light, radiant energy, electrolysis, photoelectric effect and quantum of light, Bohr's theory, spectra of atoms.

(96) Bacteria, yeasts and molds; physiology, morphology, and systematic relationships; the significance of bacterial, yeasts and molds in general sanitation, agriculture, home economics and communicable diseases.

(97) Elementary aspects of organic unit processes including nitration, sulfonation, halogenation, hydrogenation, oxidation and alkylation.

(98) Environmental testing of components, parts, and products for assessment of performance in actual application.

(99) Preparations of specimens for testing by processes such as slicing, polishing, electropolishing, etching, dyeing, and impregnating.

TABLE I

Distribution of Responses Among Eight Categories on 99 Items of the Card Sort (N = 348)

Item	Value Assigned by Respondents									
	0	1	2	3	4	5	6	7	Σ	Rank Order
1	93	1	2	22	62	65	67	36	1298	97
2	305	1	3	4	11	10	9	5	202	23
3	92	0	7	34	53	83	45	34	1251	95
4	212	3	14	29	32	27	15	16	583	63
5	318	0	2	5	4	9	8	2	142	16
6	292	2	10	13	10	11	5	5	221	25
7	272	3	12	25	15	11	9	1	278	33
8	229	4	12	17	25	25	19	17	537	61
9	303	1	4	5	10	8	10	7	213	24
10	340	0	1	2	3	1	0	1	32	2
11	340	1	6	1	0	0	0	0	16	1
12	195	4	5	34	35	28	27	20	698	73
13	339	0	0	2	1	2	3	1	45	5.5
14	329	0	4	3	3	3	2	4	84	12
15	339	0	0	1	2	3	2	1	45	5.5
16	334	0	0	2	3	4	3	2	70	10
17	78	1	1	26	53	54	65	70	1443	99
18	239	2	14	20	20	22	25	6	472	52
19	278	0	12	20	21	10	4	3	263	32
20	324	1	4	11	6	1	0	1	78	11
21	312	4	8	16	7	1	0	0	101	14
22	287	3	5	23	16	8	5	1	223	26
23	206	4	7	14	52	39	21	5	624	70
24	247	2	12	24	34	17	8	4	395	45
25	268	5	7	19	20	18	9	2	314	36
26	204	0	12	39	36	26	16	15	616	68.5
27	166	4	11	30	58	33	26	20	809	75
28	156	3	7	22	53	38	26	43	942	82
29	297	3	7	10	18	11	1	1	187	20
30	192	1	13	27	50	25	21	19	692	72
31	266	2	12	18	27	12	7	4	318	37
32	272	2	8	10	17	24	11	4	330	41
33	219	3	13	28	39	27	11	8	526	59
34	195	2	13	40	53	29	10	6	607	67
35	139	1	7	20	45	63	47	26	1034	86
36	241	2	10	25	41	23	5	1	413	49
37	134	1	8	24	37	52	55	37	1086	92
38	137	1	2	27	49	72	33	27	1029	85
39	317	1	7	7	8	5	2	1	112	15
40	332	3	8	3	2	0	0	0	36	3
41	221	2	11	22	40	35	13	4	531	60
42	183	5	7	36	51	30	23	13	710	74
43	303	3	7	20	9	4	1	1	146	18
44	148	2	8	34	50	42	44	20	934	81
45	293	1	8	16	20	7	1	2	200	22

TABLE I (continued)

	0	1	2	3	4	5	6	7	Σ	Rank Order
46	194	2	12	51	43	38	7	1	590	64
47	151	2	6	33	58	55	30	13	891	78
48	275	4	13	25	22	7	2	0	240	30
49	249	2	13	36	31	14	3	0	348	43
50	273	4	17	23	26	5	0	0	236	29
51	127	2	9	26	47	58	51	28	1078	90
52	120	2	4	30	70	80	33	9	1041	87
53	90	0	4	19	65	102	55	13	1256	96
54	251	4	15	36	33	8	1	0	320	38
55	316	1	11	10	7	3	0	0	96	13
56	208	3	19	36	56	18	8	0	511	56
57	240	3	11	14	19	17	23	21	513	57
58	222	3	9	39	42	26	3	4	482	54
59	216	2	17	39	49	21	4	0	478	53
60	218	1	12	34	47	30	6	0	501	55
61	130	0	4	16	64	61	55	18	1073	89
62	334	0	1	2	3	4	4	0	64	8
63	134	2	9	17	45	69	44	28	1056	88
64	255	1	11	21	27	20	8	5	377	44
65	120	2	5	31	50	79	40	21	1087	93
66	85	1	0	13	63	72	89	25	1361	98
67	103	2	1	21	61	67	51	42	1246	94
68	276	3	8	19	24	8	3	7	279	34
69	287	2	14	16	12	8	5	4	224	27
70	148	0	6	35	62	50	30	17	914	80
71	262	3	4	15	17	18	17	12	400	47.5
72	150	1	10	16	39	55	44	33	995	83
73	156	1	10	25	41	58	39	18	910	79
74	328	3	5	1	8	1	0	2	67	9
75	209	3	5	20	49	33	21	8	616	68.5
76	261	1	5	27	32	15	5	2	339	42
77	124	1	5	21	73	61	30	33	1082	91
78	335	1	2	4	2	2	1	1	48	7
79	170	1	10	21	29	45	46	26	883	77
80	165	1	14	26	60	30	33	19	828	76
81	245	1	8	18	27	23	22	4	454	51
82	301	2	5	13	10	9	6	2	186	19
83	231	1	7	16	20	19	17	37	599	66
84	240	4	11	18	30	30	11	4	444	50
85	233	1	8	16	29	16	29	16	547	62
86	278	1	6	17	15	20	6	5	295	35
87	339	0	1	0	6	1	0	1	38	4
88	288	1	5	19	17	13	4	1	232	28
89	190	4	9	31	54	40	18	2	653	71
90	243	4	10	36	27	14	11	3	397	46
91	274	3	10	33	21	6	1	0	242	31
92	247	2	14	19	31	23	10	2	400	47.5
93	199	2	10	36	56	30	13	2	596	65
94	309	2	7	8	12	6	3	1	143	17
95	270	3	3	12	32	19	4	5	327	39.5
96	304	2	5	8	7	9	10	3	190	21
97	272	1	9	13	19	15	15	4	327	39.5
98	140	1	7	19	57	55	30	39	1028	84
99	231	1	7	23	32	26	18	10	520	58